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CONTENTS

Protection of the Watershed of the Newark Water Works. By Morris R. Sherrerd..... 1
Sanitation of the Croton Watershed. By T. D. L. Coffin 6
Sanitation of the Rockaway River Watershed. By Charles F. Breitzke..... 14
The Sanitation of Watersheds. Discussion of Preceding Pages..... 30
Electrolysis. Discussion at New York Section Meeting. 38
Some Observations upon Public Regulation of Water Works. By Leonard Metcalf..... 46
The Sioux City Booster Station. By Philip Carlin... 58
Experience in Handling Bad Water Complaints and Laboratory Control. By Earl T. Kirkpatrick..... 62
The Sanitary Drinking Fountain. By J. H. Dunlap... 65
Treatment of Missouri River Water at Council Bluffs, Iowa. By J. B. Thornell..... 70
Some Problems of the Water Works Executive. By Garrett O. House..... 78
Swimming Pool Operation. By Jack J. Hinman, Jr... 86
The Water Supply of the Quad Cities. By Martin R. Carlson..... 104
An Inverted Siphon in a Suction Line. By Karl C. Kastberg..... 110
The Use of Water Meters. By J. C. Beardsley..... 114
The Fallacy of Extending Service Connections to the Curb Line Previous to Paving. By John Wilson.. 121
The American Committee on Electrolysis..... 125
Minnesota Section Meeting, December 2, 1916..... 126
New York Section Meeting, December 20, 1916..... 126
Membership Notes..... 127

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PROTECTION OF THE WATERSHED OF THE NEWARK WATER WORKS[1]

BY MORRIS R. SHERRERD

In providing for the protection of the gravity water supply of Newark, New Jersey, the board in charge went so far as to secure legislation authorizing the construction of sewerage systems in the watershed at the city's expense. The law permitted the board to enter on any property and connect the outhouses and other toilet facilities with such sewers, and this was opposed by some of the parties affected by it. In the small town of Newfoundland, where the population was more congested than elsewhere in the watershed, the board proposed to install not only a sewerage system at the expense of the city of Newark but also a water system, and to charge only $5 per year per house for water. The opposition in this case was so great that the board changed its policy and instead of installing sewer systems it decided to acquire property. In 1900 the city of Newark owned only about 7,000 acres, including the area occupied by the reservoirs, while today it owns about 43 of the 63 square miles embraced in the watershed.

The supply comes from 63 square miles of the watershed of the Pequannock River, a tributary of the Passaic River, about 30 miles from the city. There are two pipe lines, 42 and 48 inches in diameter, with a receiving reservoir at Cedar Grove about 10 miles from the city. The two pipe lines have a daily capacity of about 50,000,000

[1] An informal address explaining a series of lantern slides shown at a meeting of the New York Section on December 20, 1916.

gallons. The effect of the construction of new works and the increase in the consumption of water on the cost of water per million gallons is shown by the following figures. In 1892 the city paid $4,000,000 on account of its water works and the cost of water at that time was about $50 per million gallons, but by 1900 the cost had run down to $26 as a result of increased use of water. In the latter part of that year $2,000,000 was invested in the water works and the cost of water was run up to $38. The payment for the Cedar Grove reservoir in 1905 increased this cost to $40, but growing consumption has gradually brought it down to $30 now. This is for water delivered into the city's reservoirs and includes sinking fund charges and the maintenance of the watershed and Cedar Grove reservoir. In 1922, when the bonds have been retired, the cost of water to the city from this source will be under $5, although the average cost of water for the city will be more because the existing supply must be supplemented by a supply from another source.

In addition to the expenses for the development of its water supply the city has outstanding $1,300,000 in bonds for the acquisition of properties, mainly for the purpose of preventing the pollution of the water. Most of this land is under forestration, and the accompanying illustration of one of our forest lookouts discloses one of the duties of our foresters. The city has built a number of them, each with a telephone connection, and in each is stationed a watchman paid by the United States government. If he detects a fire he telephones at once to the nearest fire warden. This year, which has been a rather wet one, we have put out 315 fires by means of this system, which is under the general charge of the State Forestry Department of New Jersey. In carrying on the forestry work the city has set out about a million trees, and now has a million more in its nurseries.

The acquisition of watershed property has had a marked effect on the population. In 1900 the population was probably between 35 and 40 per square mile. The acquisition of farms and the removal of three hotels brought this down to 16 per square mile of permanent residents and 5 per square mile of summer boarders. The acquisition of this property has not been without its troubles and its amusing side as well. A woman owning land which drained in part toward the Oak Ridge Reservoir and in part toward the Clinton Reservoir wished to have the property given a double valuation because those dwelling there "pollute both ways." The

toilet compartments on the cars of the railroad traversing the watershed are kept locked while crossing it.

In tearing down the houses, a large amount of lumber was salvaged and used in building the houses in a model village just below Macopin Intake. Formerly the farms acquired to prevent pollu-

FIG. 1. OBSERVATION TOWER FOR FOREST FIRES

tion were turned over to the board's men as tenants, but this did not seem in accordance with sanitary precepts so it was decided to construct a village for them, with a school-house, church and fire-house. Very little new lumber is needed for these buildings.

A few figures will prove the benefits received from this work on

FIG. 2. VILLAGE FOR CITY EMPLOYEES BELOW THE WATERSHED

Most of the material used in building was obtained from buildings torn down in watershed.

FIG. 3. MACOPIN INTAKE

the watershed. The average number of bacteria per cubic centimeter in the water at Macopin Intake dropped from 1100 in 1902 to 690 in 1910 and 511 in 1915. The decrease of the number of times that the bacteria in 0.5 cc. caused fermentation has been even greater, the figures by percentages of the total number of samples being:

	YEAR				
	1900	1908	1913	1914	1915
Bacteria	87	75	40	32	24

The number of times that the bacteria caused fermentation per 0.5 cc. of the water in the Cedar Grove Reservoir has decreased also by percentages as follows:

	YEAR								
	1906	1907	1908	1910	1911	1912	1913	1914	1915
Bacteria	67	70	50	22	36	50	17	5	5

Statistics compiled by Mr. Rosentreter show that there were 130 cases of typhoid fever per 100,000 population in 1900, when 93 per cent of the watershed was privately owned. In 1905, when 80 per cent of the watershed was privately owned, the case rate had dropped to about 80. 1910, the case rate was 52 and 56 per cent of the property was privately owned. In 1915 the case rate was 28 and 35 per cent of the property was privately owned. This rapid reduction in the typhoid fever case rate was not wholly due to the cleaning up of the watershed, however, for it was brought about in part by the improvement of the general sanitation of the city.

SANITATION OF THE CROTON WATERSHED[1]

By T. D. L. Coffin

The Croton watershed, covering 375 square miles principally in northern Westchester and Putnam Counties, New York, supplies part of the water consumed in the Boroughs of Manhattan and The Bronx, New York City. From it, there is a present daily draft of 350,000,000 gallons. The storage capacity of the various reservoirs within the watershed is 104,000,000,000 gallons, or about 280 days' supply under the present draft. This long storage is an important element in securing a surface water of low bacterial content.

Within the watershed there is a population of about 25,000; there is one community of 3000, another of 1500, a third of 1200; four between 500 and 1000; 16 of 100 to 500, and 22 named communities with a population under 100. The remainder of the population, or about 13,000, are rural residents.

As a portion of the watersheds division of the bureau of water supply, an organization devoted to the sanitation of the watershed is maintained. It is composed of two engineering assistants, one typist, 21 inspectors under the immediate direction of a chief inspector, one machinist, one autobomile engineman, and eight laborers. As required, additional laborers assigned elsewhere in the division are temporarily detailed to sanitation.

Inspection. For its sanitary patrol the watershed has been divided into 21 districts, to each of which a watershed inspector is assigned. In the boundaries of these districts consideration was given to the proximity of aqueduct intakes, population, popularity of the lakes for outing and fishing parties, length and number of tributary streams, length of lake margins and similar features. Each inspection district is further divided into a number of patrol routes, and once each month a patrol schedule is prepared indicating the patrol route for each inspector for each day of the month. In this way it is known that the entire watershed is covered at proper intervals and an excellent check is had upon the inspectors. In cover-

[1] Read at a meeting of the New York Section, December 20, 1916 and illustrated with lantern slides of the several structures mentioned.

ing these routes the inspectors note any new condition likely to cause contamination, any change of a previously reported violation or nuisance, new building construction of any sort, make inquiries as to cases of typhoid fever, dysentery or poliomyelitis, use disinfectants where necessary, insure that boats are kept in a cleanly condition, prevent bathing in reservoirs, use algaecides where required in small amounts, and post trespass signs upon the city property margins. The men assigned to this work are considerably above ordinary laborers in intelligence, are per annum employees, work each day of the year excepting for a two weeks vacation, and will shortly appear in uniform.

This work of sanitary inspection was begun about 1888, and in 1892, during the administration of Mayor Gilroy, Commissioner Michael T. Dailey ordered a general clean-up of the watershed. Thousands of dollars were spent at this time resulting in the destruction or removal of many dwellings, stables, privies, slaughter houses and drains located in close proximity to streams. At this time the first community disposal system in the watershed was constructed when a portion of the village of Brewster was sewered. The sewage so collected was treated with electrozone by the Wolff process, previous to absorption in the soil. The electrozone plant was continued in service until destroyed by fire in 1911.

Our present records, probably begun in 1897, indicate that over 3200 violations of the rules of the State Department of Health have been discovered, of which 124 are unabated. These, of course, are receiving active attention looking to their early correction.

Commencing November, 1913, the inspectors were notified to report the conditions of premises upon which buildings were about to be erected in locations such that contamination might result. In all such cases, numbering 320 to date, appropriate letters have been sent to the owners, together with a copy of the rules of the state department of health, so that at the time of construction proper means for the disposal of all wastes might be provided. This has worked out very satisfactorily and it is found that owners approached in this way are generally ready to consider the city's interest in the premises.

Typhoid fever. The department is particularly concerned that proper precautions be taken in all typhoid fever cases occurring within its watershed. With few exceptions, cordial relations exist between its employees and physicians practising within the water-

shed so that physicians usually inform the local inspectors of all suspected cases. In rural communities news travels rapidly so that inspectors, for the most part long resident within their districts, secure their first information by hearsay should the physician fail to give notice. During one year the department checked its cases against those reported by law by the local health officers to the state department of health and failed to find that local cases had escaped our earlier attention, so that there is good reason for believing that our records show all the cases occurring within the watershed.

Upon first notice of a suspected case, a careful examination of the premises is made to insure that all dejecta are cared for in such manner as to be harmless; the history of the case is obtained to learn, if possible, the source of infection; disinfectants are supplied to be used under the direction of the physician; samples of water and milk are analyzed; specimens from the patient are taken and returns made to the attending physician. If the case proves positive, the premises are frequently inspected to make certain that the nurse or other attendant is continuing necessary precautionary measures, immunizing material is furnished the physician whenever he can persuade the other members of the family to accept treatment. After convalescence, feces samples are taken some ten days after the patient's temperature becomes normal and at ten-day intervals until two successive negative returns are obtained. Until such returns are received, the local physicians will usually require the patient to remain isolated.

Our records indicate the following cases of typhoid fever annually within the watershed beginning 1910: 23, 22, 17, 9, 19, 12 and 3 to October 1 of the current year. There have been many suspected cases to which considerable preliminary attention has been given, but the diagnosis has proved negative.

Dead animals. Presumably no more animals die upon this watershed than upon a similar area elsewhere, yet the yearly total of animals whose burial is looked after by this department is surprising. For instance, during 1915, the following dead animals found within pollutable distance of a reservoir or stream were properly disposed of under direction of the sanitary force:

Large domestic animals	303
Small domestic animals	247
Wild animals	367
Fish	11,890
Total	12,807

Copper sulphate. Owing to the large area of shallow flowage in the reservoirs, microscopic organisms objectionable for the tastes, colors, and odors they produce are prevalent and to hold these growths in check copper sulphate is used. This material is dissolved in the usual manner by trailing it in bags behind a boat. For treating large areas of deep water in Croton Lake, a motor launch is available and capable of distributing about 1000 to 1500 pounds of chemical in eight hours. Shallow areas and all secondary reservoirs are treated either with row boats or boats fitted with detachable motors, of which two are available. Row boats will distribute 300 to 500 pounds of copper sulphate per day of eight hours and those fitted with detachable motors about twice this amount. In treating a reservoir, a map of it is first divided into a number of smaller areas by drawing lines from prominent land marks and the area of each section determined by planimeter. The weight of the water in each sub-division is then determined, it being assumed for this purpose, that all water 10 or more feet below the surface requires no treatment, and from this the amount of copper sulphate to be used is determined. The usual dilution is 1:3,000,000 to 1:5,000,000, depending upon the organism present. The boatmen are instructed as to landmarks and the treatment is made as evenly as possible over the area in question. Often it is noted that only small bays or coves are affected, in which event a local application is made. In some cases the area affected is so slight that the treatment may be made from shore, the bag of sulphate being trailed from a pole. It is believed that these partial treatments are very necessary to prevent the growth spreading over the entire water surface. Last year about 15,000 pounds of copper sulphate was required and the year before 30,000 pounds.

Dunwoodie chlorination plant. All the water delivered to the city through the old and new aqueducts is chlorinated at a plant located at Dunwoodie, Yonkers, New York. This plant is now of a dual type, it being possible to treat the flow with either "bleach" or liquid chlorine. The latter treatment is at present in use and will be continued, barring accident, unless a change in the market renders the bleach treatment of less cost. This plant was described in detail in *Engineering News*, February 27, 1913, and September 7, 1916.

Sewage treatment plants. At Mt. Kisco, N. Y., the City of New York has built and operates a sewage disposal plant treating

the sewage of that village. It comprises settling tank, contact beds, sand filters and a disinfecting plant. The village built and maintains the lateral and trunk sewers.

At Brewster, New York, a portion of the village is sewered and the sewage so collected, amounting to some 10,000 gallons daily, is chlorinated and conducted to a settling basin and tile field. It is realized that this arrangement is somewhat peculiar in that the use of chlorine previous to settling lessens materially the hydrolitic action that would materially lessen the amount of solids, and, perhaps, even lessens the oxidizing process that might be expected to occur in the tile field, but the topography is such that it was necessary to parallel a reservoir margin for a distance of about two miles with the sewer line to reach an area available for a disposal field and to avoid the possibility of introducing raw sewage into this reservoir through mischance with the sewer, the unusual arrangement was decided upon. Owing also to this location of the sewer, enough chlorine is used to insure a sterile sewage, requiring 400 parts per million.

Kisco River chlorinating plant. Kisco River is the largest affluent of Croton Lake, discharging into that body of water without having passed through a reservoir. It receives all the street wash of the village of Mt. Kisco and the effluent of the disposal plant for this village. For these reasons, the waters of this stream have been continuously chlorinated since 1911, when a bleach plant was first placed in operation. At the present time, a gas plant is being constructed to take its place. The construction is such that a portion of the river flow, 50,000 gallons per day or more, may be diverted from the river channel into a chlorinating well with its bottom 6 feet below the river bed. Dry feed, manual control chlorinators will deliver chlorine to diffusers located at the bottom of this well, and this chlorine solution will then be returned to the river, there to mix with the regular flow.

Katonah chlorinating plant. The greater part of the street wash and yard runoff from premises in Katonah enters directly into Croton Lake through a small stream known as Katonah brook. To insure against danger in this quarter, the department operates a chlorinating station on this stream. This is a bleach plant and embodies no unusual features. A duplicate plant is located at the outlet of Lake Gleneida, which in part is subject to street drainage. This plant is operated part time only.

Tonetta Brook. As a part of the plant already mentioned as treating the sewage of Brewster, provision is made for chlorinating the flow of Tonetta stream before it enters the diverting reservoir. This is a bleach plant built in 1911, replacing an electrozone plant which burned to the ground that year. It is of interest that the cypress solution tanks are still in a watertight condition after five years of continuous service. After erection the tanks were given an interior coating of cement plaster on metal fabric and were then painted inside and out with a coat of minwax.

Upon Charter Brook, another stream flowing through the village of Brewster, a sedimentation basin and sand filter have been provided. Except after exceptionally heavy or protracted storms there is no overflow from these beds and it is hoped that a chlorinating plant may be installed soon to treat such overflow.

At Purdy's Station a small filter basin has been constructed through which the road wash of this community must pass before entering Croton Lake.

Institutional sewage treatment. In addition to the plants operated by the city, there are in the watershed several institutional sewage disposal plants, oversight of which is exercised by the department.

At the Montefiore Home, Bedford Hills, New York, the sewage is disposed of in a plant consisting of septic tanks, dosing chambers, sprinkling filters, the effluent of which is chlorinated and run out into a series of trenches following the contours of a hillside. The chlorinating apparatus is a recent addition to the plant originally installed after plans prepared by Messrs. Hering and Fuller. The inmates at this institution average about 200 and the daily water consumption varies from 20,000 to 30,000 gallons daily.

At the Bureau of Social Hygiene, Bedford Hills, New York, there is a sewage disposal plant designed to handle the sewage from 100 persons and consisting of Imhoff tank, dosing chamber and tile field, divided into four sections and located in a natural sand basin from which there is no surface outlet.

At the New York State Reformatory for Women at Bedford Hills, N. Y., the sewage from 600 persons is cared for in a plant first operated January 11, 1916, plans of which were prepared by the state architect. The plant includes a screen chamber, three Imhoff tanks, sludge bed, eight sand filters, chlorine gas machine and appurtenances.

At the Lincolndale Agricultural School, Lincolndale, New York, a plant treats the sewage from about 250 persons. This plant,

designed by N. S. Hill, consists of septic tanks, dosing tanks, contact beds and sand filters, the effluent of which is chlorinated by the use of bleach.

At the Waccabuc Inn, Lake Waccabuc, New York, a plant designed by Lederle and Provost treats the sewage from a summer hotel population by sedimentation, filtration and chlorination.

At the Mountain Spring Farm, Brewster, New York, a plant designed and constructed by the New York Sewage Disposal Company treats the sewage derived from a sanitarium of about 50 inmates. This plant comprises a septic tank, sand filters and an irrigation field.

At Carmel, upon New York the premises of Ryder Brothers, there is a plant treating the sewage derived from 40 to 50 persons. The arrangement of the tile field at this plant is of interest in that the tile runs, each 200 feet in length, follow a contour of a steep hillside. At the middle of each tile run there is a diverting unit, a small concrete box with an inlet near the top and an outlet at the bottom. Between the inlet and outlet pipes there is a movable stop plank which, when in place, allows the sewage to rise and flow into the tile line. Any flow in excess of the capacity of the particular run passes over the stop plank to the next lower diverting unit. By raising the stop plank all sewage passes into a lower unit and opportunity is afforded for the drying out of the soil about a used tile run.

In addition to the larger plants described above, there are numerous smaller plants scattered about the watershed serving single residences, hotels and homes. These generally are of the septic tank, siphon chamber, tile field type. In one case the discharge from the siphon chamber is sprayed onto a rocky hill. The premises, however, are occupied only during the summer months. In two instances modified Imhoff tanks replace the ordinary single story settling tank. The tendency in single story settling tanks is toward a baffled rather deep narrow tank, having an area of about 2 square feet per person served, and away from a circular tank of brick, as affording a more uniform flow. In several instances these tanks have sloping bottoms with piping for blowing out the sludge at intervals.

Many styles of tile are used in the absorption fields; some of the more expensive are rectangular in shape and divided into several compartments. Some designs employ a two or three-way gate for

diverting the sewage from one to another portion of the tile field while others use a specially designed Y tile with a ridge extending along a portion of the invert so that a siphon discharge is divided among several runs of tile, this method sometimes being employed when the tile runs are upon a hillside. It is not known that any particular shape of tile has a distinct advantage over the plain round glazed drain tile, without bell or collar, when these are laid in a field with provision for frequent rest periods. The length of tile per person varies with the character of the soil and the designer of the system but probably averages from 25 to 40 feet per person. They are laid upon a very flat grade.

SANITATION ON THE ROCKAWAY RIVER WATERSHED[1]

By Charles F. Breitzke

Jersey City is not as fortunate as Newark in having a watershed which it is feasible to own and from which the residents can be removed at will. It can never expect, therefore, to have the ideal catchment area which Newark is gradually evolving, and the problem which Jersey City must solve is to procure a wholesome water supply in a region where conditions are aggravated by the density of a rapidly increasing population. The present supply, taken from the Rockaway River at Boonton, is obtained from a watershed having a population slightly in excess of that on the Croton watershed in a little less than one-third the area. The topography and geology of the Rockaway River watershed bear such an intimate relation to the distribution of the resident population and sanitary problems, that it has seemed best to consider these briefly first.

PHYSICAL CHARACTERISTICS OF ROCKAWAY RIVER WATERSHED

Location of watershed. Jersey City's watershed lies in the Highlands of Northern New Jersey, and with the exception of a small portion in Sussex County, the territory drained by the Rockaway River above the Boonton Dam is located in Morris County. The boundaries of the watershed and of the different tributary streams are shown in the accompanying map (Fig. 1.)

Course of river. The Rockaway River has its source in the Longwood Valley, in which it flows in a southwesterly direction to Wharton, where it takes a tortuous course in an easterly direction guided by steep protruding hills. Winding from side to side in an irregular defile, it flows across three parallel valleys, namely that of Green Pond Brook, that of Mill and Beaver Brooks, and that of Den and Stony Brooks. The main stream flows through each of these valleys in succession until a depression in the ridge enables it to cross to the next valley. On reaching Powerville it takes a southeasterly and southerly course to the reservoir at Boonton.

[1] Read at a meeting of the New York Section, December 20, 1916.

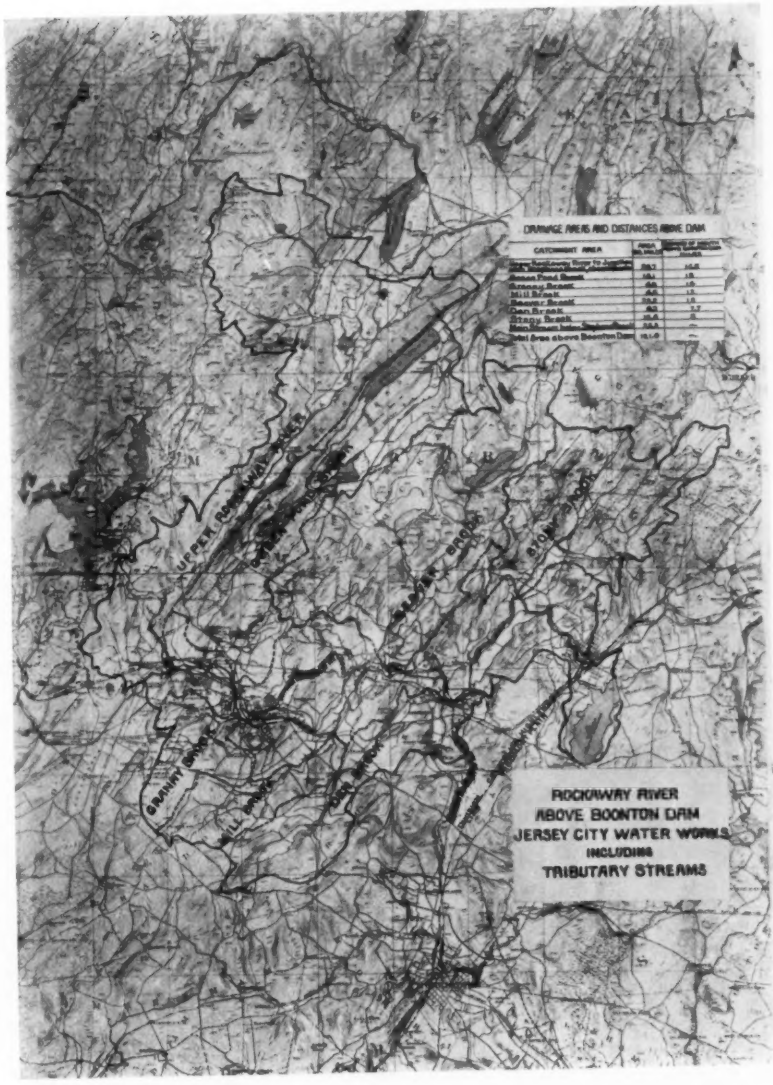


FIG. 1. WATERSHED OF THE JERSEY CITY WATER WORKS

The drainage area to the south extends but a few miles back from the river and the streams draining this section are small. Practically all the important tributaries thus enter from the north in a direction almost opposite to the main stream.

Areas. The area of the entire watershed and its larger subdivisions together with the distances of the mouths of the larger tributaries from the Boonton Dam, are given in the accompanying table.

Drainage areas of Rockaway River catchment basin and distances above Boonton Dam

CATCHMENT AREA	AREA	DISTANCE OF MOUTH ABOVE BOONTON DAM
	square miles	*miles*
Upper Rockaway River to junction with Stephen's Brook above Wharton	29.7	16.5
Green Pond Brook	16.1	15.0
Granny Brook	4.3	14.0
Mill Brook	4.5	12.0
Beaver Brook	22.2	10.0
Den Brook	8.3	7.7
Stony Brook	12.6	5.0
Main stream below Stephen's Brook	23.3	
Total area above Boonton Dam	121.0	

Underlying rock. Three geological formations occur within the watershed, designated respectively as the Crystalline Highlands, the Green Pond Mountain Belt and the Piedmont Plain.

The first of these forms about 80 per cent of the watershed and consists largely of syenite, granite, gneiss and other crystalline schistose rocks and beds of magnetic iron ore. At Boonton, just above where the river enters the reservoir, this formation is separated from the so-called Piedmont Plain by a fault. All of the watershed west of this fault at Boonton, and east and west of the Green Pond Mountain Belt, as well as a narrow strip between Green Pond Mountain and Copperas Mountains, belongs to this formation.

The Green Pond Mountain Belt is a comparatively narrow zone of conglomerate, sandstone, shale and limestone infolded and downfaulted into the ancient crystalline rocks. This formation is represented on the watershed by Green Pond and Copperas Mountains,

noted for their rugged character and cliffs and peculiar reddish conglomerate studded with white quartz pebbles. There are a very few outcrops of limestone in this belt, for the most part hard magnesium limestone. The effect of these on the hardness of the water is insignificant.

The rocks of the Piedmont Plain belong to the Newark formation. This section of the watershed was once part of the ancient Lake Passaic. The rocks consist of great thicknesses of alternating sandstones and shales. The Boonton Dam and reservoir were built in this formation.

Effects of the ice sheet on topography. Another geological feature having an important bearing on the sanitary problems of the watershed is the change in the topography caused by the great ice sheet which covered Canada and northern United States. There is a marked difference in surface conditions north of the terminal moraine and those south of it.

North of the line the ridges were denuded of all disintegrated rock, transverse depressions were scooped out where the rock was soft, and hard bare summits and irregular jagged ridge lines were left. The slopes were left covered with boulders and in the valleys great masses of gravel and mud were deposited, the thickness of which varies from zero to known depths of more than 250 feet. Much of the soil was rendered unfit for cultivation, by the action of the ice sheet, and a large percentage of the area has been left in forest.

South of where the ice sheet extended, on the other hand, there are but few outcrops of rock, the latter being usually disintegrated and weathered to a considerable depth. The ridges are well covered with soil, the valleys are free from boulders, and consequently the land is more adaptable to tillage than north of the terminal moraine.

Forests. The average forested area for the whole watershed is over 80 per cent. Southwest of Dover and Denville, which are near the terminal moraine about half of the country is in timber. North of the terminal moraine large areas are in forest and the cleared portions are for the most part grass lands. In fact, very few farms are now being worked, the population in the outlying districts is decreasing and in many instances cleared land is lapsing back into forest. It is estimated that nearly 90 per cent of this area is in forest.

Swamps. All valleys contain swampy bottoms, and swamp lands comprising about 3 per cent of the whole drainage area. About half of this is peaty, but its effect on the quality of the water is negligible except in the case of the first run-off following periods of drought, when some color is imparted to the water. While the percentage of swamp lands is very small, they interfere with farming and thus contribute to restrict rural population.

Run-off. Generally speaking, the watershed above the Boonton Dam naturally has a rapid rate of flow. The valleys which the main stream crosses are short, narrow, rocky and bounded by steep slopes, and this formation brings most of the head-waters close to the main stream and causes a rapid run-off.

There is a great variation in rain-fall and stream flow, and periods of drought followed by heavy run-off occur quite frequently. On the other hand underground storage in the drift of the valleys, assisted by the extensive forested areas, combined with leakage from a large number of former forge ponds, produces a fairly well sustained dry-season flow.

Summary. Physically the watershed of the Rockaway River is a desirable gathering ground for a public water supply and yields a soft clear water, usually low in color. The surface conditions are for the most part unfavorable to farming, and outside of the district bordering the main stream, comprising less than one-fifth of the drainage area, the population is either at a standstill or decreasing. On the other hand the rapid run-off after periods of drought followed by heavy rainfall, the coarse glacial drift underlying the most thickly settled district, and the nearness of most points on the watershed to the gate-house at Boonton, offer sanitary problems of considerable magnitude.

SANITARY CONDITION OF WATERSHED

Distribution of population. The depression by which the Rockaway River crosses the highland region is the route of one of the main highways throughout northern New Jersey and all the incorporated towns and boroughs in the watershed are located near the main stream.

The accompanying table gives the estimated present population on the watershed by civil divisions. Where these extend beyond the limits of the catchment area, only populations actually within the watersheds limits are given.

Population on Rockaway River watershed

CIVIL DIVISION	POPULATION OF PORTION IN WATERSHED	
	Permanent	Summer
Boonton Town	3,400	3,600
Boonton Township	550	650
Denville Township	1,000	1,500
Dover Town	11,000	11,000
Hanover Township	800	1,700
Jefferson Township	500	550
Montville Township	50	100
Pequannoc Township	50	100
Randolph Township	1,700	1,700
Rockaway Borough	2,300	2,300
Rockaway Township	3,000	3,600
Roxbury Township	100	150
Wharton Borough	3,000	3,000
Sparta Township	50	50
Total on watershed	27,500	30,000

The distribution of the population among the catchment areas of the principal tributary streams is given in another table. In this table the term "urban" refers to the residents of the towns, boroughs, thickly settled unincorporated communities, mining camps and such summer resorts as have permanent buildings.

Distribution of population on catchment areas of tributary streams

STREAM	AREA	POPULATION 1916			POPULATION PER SQUARE MILE		
		Total	Urban	Rural	Total	Urban	Rural
	square miles						
Upper Rockaway River above Wharton	29.7	750		750	25		25
Green Pond Brook	16.1	1,300	1,050	250	81	65	16
Granny Brook	4.3	700	200	500	163	47	116
Mill Brook	4.5	400		400	89		89
Beaver Brook	22.2	2,000	1,350	650	90	61	29
Den Brook	8.3	1,750	1,300	450	211	157	54
Stony Brook	12.6	700		700	56		56
Main Stream	23.3	22,400	20,100	2,300	962	863	99
Total Watershed	121.0	30,000	24,000	6,000	248	198	50

Details of the distribution of the "urban" population are given in a third table. From this it can be seen that 80 per cent of the

Distribution of urban population

NAME OF SETTLEMENT	GREEN POND BROOK	GRANNY BROOK	BEAVER BROOK	DEN BROOK	MAIN STREAM	TOTAL
Boonton					3,600	3,600
Cedar Lake					300*	300*
Denville				150	200	350
Mt. Tabor				1,150*		1,150*
Rockaway					2,300	2,300
Upper Hibernia			200			200
Lower Hibernia			250			250
Mt. Hope			900			900
Green Pond	600*					600*
Richard Mine	350					350
Dover		150			10,850	11,000
Wharton	100	50			2,850	3,000
Total	1,050	200	1,350	1,300	20,100	24,000

* Chiefly summer residents.

entire population on the watershed is concentrated in small areas along or near the main stream. With the exception of Green Pond, where there is only a summer population which is being properly served by privies and cesspools and no sewer system is needed, all these places are within easy reach of a trunk sewer, and if at any time the usual methods of sanitary patrol should be no longer effective in preventing pollution in any or all of these places, arrangements can readily be made to install lateral and connecting sewers.

Comparative data of population on other watersheds

WATER SUPPLY	POPULATION PER SQUARE MILE		
	Total	Sewage diverted	Sewage not diverted
Newark, N. J., Pequannock Watershed	14		
New York City, Croton Watershed	67		
Boston Metropolitan Water Supply			
Wachusett Watershed	53		
Sudbury	305	181	124
Cochituate Watershed	914	696	218

Comparative data of population on other watersheds the supplies from which are of good quality are given in an accompanying table. Comparing its figures with those in the table of the distribution of population on the Rockaway watershed, we find that, while the ideal conditions existing on Newark's watershed can never be realized in the case of Jersey City's supply, and while the population per square mile of the Rockaway watershed is high when compared to the population on the watersheds of Newark and New York, the experience in the case of the Boston Metropolitan supply shows that it need not cause alarm if proper sanitary protective measures are taken, and that water supplies from such sources are not necessarily seriously impaired by such populations if the sewage is diverted out of the drainage area.

Diversion of sewage out of watershed. In fact Jersey City has been considering such a step for some time and a movement is under way looking to the construction of a trunk sewer. Half of the population on the watershed would be immediately served by such a sewer, and shortly following its installation, it is estimated that the sewage from 22,000 or 73 per cent of the people will be diverted to some point below the Boonton Dam. This would leave on the watershed a balance of 66 people per square mile not served by sewers, of which 16 would represent small communities not having any water supply and 50 a scattered population not presenting any difficult sanitary problem.

SANITATION METHODS ON WATERSHED

Removal of sources of pollution. The laws of New Jersey are very strict with reference to the protection of public water supplies from pollution. Thus Section 1 of "An Act to secure the purity of the public supplies of potable waters in the State," approved March 17, 1899, provides:

1. No excremental matter, domestic, factory, workshop, mill or slaughter house refuse, creamery or cheese factory waste, garbage, dye stuff, coal tar, sawdust, tan bark or refuse from gas houses or other polluting matter shall be placed in, or discharged into, the waters, or placed or deposited upon the ice of any river, brook, stream, or any tributary or branch thereof, or of any lake, pond, well, spring or other reservoir above the point from which any city, town, borough, township, or other municipality, shall, or may obtain its supply of water for domestic use; nor shall any such excremental matter, domestic, factory, workshop, mill or slaughter house refuse, creamery or

cheese factory waste, garbage, dye stuff, coal tar, sawdust, tan bark or refuse from gas houses, or other polluting matter, be placed or suffered to remain upon the banks of any such river, brook, stream, or of any tributary or branch thereof, or of any lake, pond, well, spring, or other reservoir, above the point from which any city, town, borough, township or other municipality shall or may obtain its supply of water for domestic use as aforesaid; and any person or persons, or private or public corporation, which shall offend against any of the provisions of this section, shall be liable to a penalty of one hundred dollars for each offense; and each week's continuance, after notice by the State or local board of health to abate or remove the same, shall constitute a separate offense; provided, however, that nothing in this section contained shall be construed to repeal, modify or otherwise affect any law or statute now conferring upon any local board of health the power of authority to institute any proceedings in any court of this State for the recovery of any penalty for, or obtaining any injunction against, the pollution of any of the waters of this State.

Regulations 3 and 4 of the new State Sanitary Code, which have all the force of law, go still further and prescribe:

Regulation 3. No person or private or municipal corporation shall maintain, use or permit to be used, any privy, or other receptacle for human excrement, ... unless such excremental matter shall at all times be prevented from flowing over or upon the surface of the ground. Every privy or other receptacle for human excrement located within 100 feet of any stream, the waters of which are used for drinking or domestic purposes, shall be provided with a water-tight vault.

Regulation 4. No person or private or municipal corporation shall permit any human excrement, or material containing human excrement, to remain on the surface of the ground; nor shall such excremental matter or material containing such excremental matter be buried or otherwise disposed of within 100 feet of any stream, well, lake, spring or other source of water used for drinking or domestic purposes; nor shall any such material be deposited in any place where it is likely to gain access to such waters. Provided, however, that this regulation shall not apply to effluents from sewage disposal plants which have been, or hereafter may be, approved by the State Department of Health.

These laws and regulations are very explicit and place the burden of removing sources of pollution on the offenders. On the surface, therefore, it would appear easy to enforce them. In fact, good results have been obtained in this manner in the outlying districts where existing violations are usually open, isolated, and readily detected.

When it comes to enforcing these laws under difficult conditions, such as are frequently found in thickly settled communities, the re-

moval of pollution in this manner is not an easy matter. In this country we cannot enforce sanitary laws as is done in Germany. In order to successfully prosecute offenders, it is necessary that the delinquent be identified, and the offense traced directly and surely to him, with specific proof as to the time and place, and the isolation of his particular offense from the offenses of others unknown.

The proof of pollution depends on circumstances. Often this is a simple matter. Thus, if polluting matter is found coming through a drain, and uranine dye is put into a toilet or sink on the premises under suspicion, and the color passes through, the evidence is sufficient. In many cases, however, pollution, even when clearly apparent, is a difficult matter to prove, as when you fail to get the dye through. Situations like this will occur when a cesspool is large and the amount of overflow small; also in those cases where cesspools have secret overflows which can be opened or stopped at will, or are located in cellars, as in the business section of Dover where, owing to ground-water difficulties, the temptation is great to get rid of cesspool matter surreptitiously. In a congested district where many properties adjoin and cesspools are close together, the question of fixing the responsibility for cesspool overflow is not an easy matter. Similar problems arise when cellar drains are connected to covered drains, and these are secretly used to carry away sewage. Often the points at which pollution enters and where evidence can be obtained are several blocks apart, and the matter of tracing and proving pollution is one which requires considerable patience and skill.

Moreover, it is frequently necessary to prove ownership of property as well as pollution, for at times tenants' testimony as to ownership may be wholly or partly in error, especially in the case of estates, or in sections occupied by a foreign population where agents are often taken for the landlords. In order to prosecute a case successfully, it is essential that the full correct name of the owner be obtained. Often this can be accomplished by obtaining an admission from the owner, making note of the time and date. In other cases the tenant's testimony is verified at the tax office or by talking with the assessor. Sometimes a trip to the county clerk's office is necessary.

Another important factor to bear in mind in enforcing the law, is the good will of the residents of the drainage area. The removal of pollution means expense to the property owner, and when you

touch a man's pocketbook you have a delicate situation to handle. It is essential, therefore, to avoid producing among the population of a watershed a feeling of bitterness and hostility, which would not only be certain to make the control of pollution difficult, but which may lead ignorant and malicious persons to secret acts of reprisal.

The policy which we have been pursuing with considerable success is based on the old proverb about catching more flies with a drop of molasses than with a barrel of vinegar. Most of the pollution has been removed through persuasion, and only in the obstinate cases has it been necessary to call upon the state department of health and the attorney general for assistance.

The procedure followed is, briefly, as follows: The speaker, in addition to his position as sanitary engineer representing Jersey City, was appointed an inspector of the state department of health. This gives him the right to enter private property in the performance of his duties. There are also Jersey City inspectors stationed at Wharton, Dover, Rockaway and Boonton. When cases of pollution are found, they are carefully examined, and an interview is had with the owner of the property where possible, during which the significance of the pollution is pointed out to him. Where personal interviews are out of the question, a letter is sent to the owner calling his attention to the pollution and the law violated, and asking him to abate the pollution. This letter also states that a reinspection will be made at a given date, and expresses the hope that further action to remove the pollution will not be necessary. As far as possible the cooperation of the local boards of health is obtained. In cases where the owner of the property can ill afford to stand the burden, assistance is given. This is usually in the form of labor and in making the improvement either in whole or in part.

All original inspections and reinspections are reported on special blanks provided by the state department of health, and from time to time are sent to Trenton, sorted in accordance with the status of the case as:

1. Reinspection of cases referred to the attorney general.
2. Cases of pollution found abated on reinspection.
3. Cases being taken up directly with the property owners.
4. Cases referred to local boards of health.
5. Cases requiring attention of the state department of health.

The obstinate cases comprising this last group, are as a rule, referred by the state department of health to the attorney general, who has notices to abate the pollution served upon the property owners. In many cases such a notice is sufficient, and usually with the others found still existing on reinspection, a little more persuasion secures the abatement. Thus far it has been necessary to carry only one of these cases into court.

Water-borne diseases. A careful watch is kept for cases of typhoid fever and other water-borne diseases. Through arrangements with the state department of health, there is received a copy of the record of cases as soon as they are reported. The speaker also keeps in touch with the recorders of vital statistics in the various civil divisions of the watershed, to whom, in accordance with Chapter 381 of the Laws of 1911, every physician must report within twelve hours after his first professional attendance upon any person suffering from a communicable disease. These gentlemen have been furnished with addressed stamped envelopes to use for notification of any cases or deaths from typhoid fever, grippe (an indefinite term which sometimes is used to report sickness perhaps of typhoid fever and especially in reporting deaths among the foreign population, where the physician has not been called until too late to properly diagnose the case), typho-malaria, typho-pneumonia, dysentery or other intestinal or diarrheal diseases occurring on the Rockaway River drainage area. Each case, as soon as reported, is carefully investigated and steps taken to disinfect the premises. A supply of hypochlorite of lime is also left on hand, and the place is kept under surveillance until danger is considered past. We are fortunate in having but little sickness of this character upon the watershed, and we do all we can to prevent typhoid fever from getting a foothold.

Toilets on railroad trains. The two principal railroads crossing the watershed are the Delaware, Lackawanna & Western, and the Central Railroad of New Jersey. To avoid danger of the infection of the water supply, arrangements were made through the state department of health on January 15, 1914, in accordance with "An Act to regulate the use of water closets and urinals on railroad trains and other public conveyances," approved April 17, 1909, whereby all toilets are to be closed while trains are crossing over the watershed. An inspection is made from time to time at different points to see that this order is being complied with.

Scavengers. Watch is also kept of the movements and dumping grounds of scavengers. There are three of these doing a big business at Dover, Wharton and Rockaway. The sites on which the refuse is dumped are on the outskirts of these towns at points removed from streams. The town of Boonton does its own scavenger work, the dumping being done outside of the watershed.

Supervision of industrial plants. The operations of industrial plants are also kept under surveillance. The largest of these are a paper mill at Powerville and the Liondale Bleach, Dye & Print Works at Rockaway. At the former, disposal beds have been built through which the liquid wastes soak away into the ground. At the latter, the sewage from some 300 employees is disinfected, and plans are under way to care properly for all the wastes. Inspections of these mills are made from time to time and samples of the effluents and of the river above and below the mill are taken. Samples are also taken periodically at different points on the watershed.

Patrol of river at Dover. The river at Dover is patrolled daily and all papers and other rubbish are removed. This work is also of value in discovering secret drains. The patrolman also attends to the operation of two chlorine treatment plants disinfecting the water from two polluted feeders at Ford Pond and Mercer Street.

Chorine treatment plants at Dover. These plants were placed over the outlets of two small streams draining two large sections of Dover situated in low ground having numerous blind drains receiving sewage pollution difficult, if not impossible, to trace to its sources. They were intended as temporary make-shifts to reduce the danger from possible pathogenic bacteria until such time as sewers will be built.

The outlets of these streams were formerly crooked, unsightly ditches, choked with weeds, brush and refuse covered with slime and decaying organic matter. The channels were redug, the sides walled up and the bottom paved. An inexpensive building housing chlorine apparatus was in each case placed on a platform over the stream as shown in the accompanying cut (Fig. No. 2). A weir beneath the platform serves the double purpose of making possible the introduction and absorption of the chlorine gas by increasing the depth of the water, and of measuring the flow of the water, so that the amount of chlorine applied may be regulated accordingly. A series of baffles on the down-stream side of the weir effects a thorough mixing of the chlorine with all of the pol-

luted water before it reaches the river. The application of the chlorine is made in accordance with a special chart giving the amount in terms of the depth of water over the weir.

The above chlorine machines were installed in February, 1913, and were, it is believed, the first two put out by Wallace & Tiernan. They were crude in comparison with present models, but for nearly three years gave very satisfactory service. Recently, in changing over from a troublesome hard rubber pipe distributing system to

FIG. 2. CHLORINATION STATION AT MERCER STREET

one of silver tubing, the old apparatus was replaced with up-to-date models. Our experience with the use of hard rubber in chlorine work has not been satisfactory. For some reason, whether through deterioration from natural causes, or the action of chlorine in the presence of moisture, or for both reasons, small hard rubber piping becomes brittle and easily broken and cannot be depended upon in chlorine work.

The experience with these plants is also interesting from the standpoint of applying chlorine as a gas directly to waters in shallow

streams. The small weir dams helped, but owing to their location, could not be built high enough to provide sufficient depth of water to completely absorb the chlorine. On the other hand, owing to the exposed location of the plants, the solution or wet method of applying the chlorine was out of question on account of freezing in cold weather. This difficulty was finally overcome by placing a stationary floating board over the diffusers. This intercepts escaping bubbles of unutilized gas and affords opportunity for all the chlorine to be dissolved by the flowing water.

FIG. 3. IMPROVED AND CLEANED RIVERBED

River cleaning. To persons familiar with former conditions, the most conspicuous of all watershed work is the cleaning and improvement of the river bed. Up to the time this was undertaken, the river, especially at Dover, was nothing more than a common dump, and the rubbish which had accumulated there was almost indescribable, ranging from discarded mattresses, cast-off clothing, garbage, tin cans and bottles to defunct cats and fowls. The stream spread out over its entire bed and contained many pools of stagnant

or sluggish water, having bottoms covered with green slimy algae. Weeds and underbrush which grew not only along the banks but in the bed of the stream as well, impeded the flow and enmeshed floating filth of all kinds. In a few words, the appearance of the river was disgusting.

In this work many tons of rubbish and muck were removed. The brush was cut down and burned. Following this preliminary work, the bed of the river was improved by providing a center channel to confine the low flow in a neat and attractive stream. The entire bed of the river was turned over with rakes. Large stones were used to fill in the holes and the remainder piled up neatly along the sides.

This improvement of the river bed had a very noticeable beneficial influence. The general tenor of local opinion was one of praise and commendation. In many instances adjoining property owners became interested in cleaning up their grounds. The benefits derived were twofold, namely, the elimination of the addition to the water of such objectionable bacterial life as refuse matter deposited in the stream may contain, and the moral effect which such action will have on people residing on or near the banks of the stream. When rubbish is kept out of a river and the stream is made attractive to the eye, there is less temptation to use it as a dumping ground.

While up to the present these improvements have been confined to the larger communities, it is the intention of Commissioner Henry Byrne to continue this good work and to extend it to such portions of the watershed as may be necessary.

PROF. W. P. MASON: While Mr. Sherrerd was speaking of his watershed of 63 square miles I could but think of the 67 square miles of our own lower service at Troy. It would be very expensive for a city of the size of Troy to do what Newark has done, so we are striving to get along with a cheaper plan. We have to police our watershed as best we can and see to it that nothing very serious happens. A great deal can be done by careful policing. If a local sanitary officer, by preference a local physician, be secured at reasonable expense and be empowered to employ as assistant a man of intelligence who will give his whole time to the work under the direction of the sanitary officer, much can be accomplished.

Pollution from railway trains is a young subject and has by no manner of means been fully studied. I once attempted to secure some information from a railway office as to the number of times the toilet in a car was used per mile of roadbed, but nothing could be learned.

If we had some such record the information would be useful. As matters now stand, the railway companies are expected to so look after their trains that roadbed pollution shall not damage the catchment area of any water supply. Sundry propositions are under discussion, such as locking toilet-room doors while passing points of special danger, or carrying all dejecta in a closed tank to the end of the car's run. But doors cannot always be locked as proposed, and the incipient typhoid cases, who are the most dangerous class of passengers, are the very ones who would make the locking impracticable. Carrying any type of earth closet on a car would almost certainly prove unpopular. To my mind the remedy lies with a sanitary oversight of the roadbed rather than of the rolling stock, and the entire burden of such oversight should not be borne by the railway companies.

R. E. MILLIGAN: I have heard with particular interest Professor Mason's remarks as to the difficulty of handling waste discharges

[1] Discussion of papers by Messrs. Sherrerd, Coffin and Breitzke at a meeting of the New York Section on December 20, 1916.

and pollution from railroads crossing watersheds. I suppose that the experience at Scranton, Pennsylvania, is well known to all interested in the subject, and I assume that it was clearly established there that disease was communicated to the reservoirs and passed into the water through lack of prevention on the part of the railway company whose right-of-way crossed the watershed. It is, however, the question of practically eliminating disease through the purification of such waste that appeals to me after listening to Professor Mason's remarks. Those engaged in the purification of water by filtration and sterilization, or both, are well aware of the extreme difficulty of installing practical devices that will perform the work required. There is not, nor can there be, a central point of collection, furnishing the purification plant with any measurable standardized and uniform waste to be handled. I think it would have very little effect to keep men employed in collecting the discharges on the right-of-way after the passage of trains, and would undoubtedly constitute too serious an expense when the number of trains and passengers on such a system as the Pennsylvania Railroad is called to mind.

You probably know that following the standard imposed upon steamship companies traversing the Great Lakes by the federal government, a great deal of money was expended in preventive measures so that the waters of the Great Lakes would not be contaminated through the steamship traffic and that cities taking their supplies from the Great Lakes would, at least, be free from this serious contamination. It is quite true that at the present time no satisfactory method of purification has yet been installed, although very expensive experiments were conducted, and a board appointed to pass on the various methods advocated.

The arrangements on a steamboat do not lend themselves to concentration at any particular point, nor is there any uniform use of water enabling automatic devices to be installed. It would be entirely practicable, of course, to purify a certain quantity of water and store it and have all consumers draw from the purified stored water. This is difficult as steamships are designed, and there is the greatest possible variation in the amount used per minute. Furthermore the Federal authorities impose a condition that all devices shall be absolutely automatic and dependable to no extent upon human supervision.

The purification of the water used on a steamship is governed

by a standard, and I think that Professor Mason himself was one of a committee appointed to prepare and thus responsible for this standard. My observation of this phase of the matter was that it was extremely difficult to get any real interpretation of the standard as it was submitted to the steamship companies, the federal authorities not caring to interpret it and the language of the standard being somewhat ambiguous.

The use for purified water, especially on boats carrying excursions, was at times exceedingly great and eliminated any possible storage within the confines of a steamboat. This same condition is relatively true of the purification of the waste from passengers, as this is also at times of great volume and passes into the waters of the Lakes from many different points. In fact, it would almost seem to be necessary to build a steamboat around purification plants, the one for water and the one for sewage discharges or, perhaps, it would be better to say that it is easier to impose conditions but not nearly so easy to furnish a satisfactory solution of the problems involved.

EDWARD WEGMANN: The speaker is very much interested in the description of the sanitary improvements that have been made in the Croton watershed. Twenty-five years ago the sanitary conditions in this locality were in a deplorable condition. Many outhouses were built right over brooks that flowed into Croton Lake, and heaps of manure were piled on the banks of these streams within a few feet of the water.

In 1892 a great epidemic of cholera occurred in Hamburg, Germany. It was caused by throwing the slops of a sailor sick with cholera into the river Elbe, from which Hamburg obtained its water supply. More than 8000 persons died during this epidemic. In Altona, a suburb of Hamburg, the epidemic did not prevail. This was due to the fact that, while the citizens of Hamburg drank raw river water, the river water was filtered through sand at Altona before it was distributed for domestic consumption. This is one of the strongest proofs we have that disease germs can be removed from water by slow filtration through sand. Great fears were entertained that the epidemic of cholera might spread to New York, and stringent measures were taken to prevent such a calamity. In 1893 an act known as the Webster Law was passed by the state legislature to enable the city of New York to clean up the Croton

watershed. Under this act, which was in force for three years, the commissioner of public works of New York was given great powers. He had authority to remove summarily any source of pollution, even to order people to move out of houses that were thought to endanger the public health and to set fire to them.

The commissioner who was then in office made several sanitary raids in the Croton watershed. He was accompanied by many of his subordinates and by numerous reporters. The weather was very cold at that time, and to prevent any member of the raiding party from getting sick from exposure to the elements, several bottles of some kind of amber liquid were taken along. In fact the commissioner had always one of these bottles in the pocket of his ulster and treated his friends liberally to the contents in order to preclude the possibility of their getting sick. A few sources of pollution were removed and one dirty building was burnt to the ground, after being photographed and measured. After the novelty of these raids wore off, the commissioner delegated all his authority under the Webster act to the division engineers of the aqueduct commission, who were at that time in charge of the construction of reservoirs in the Croton watershed. As one of these division engineers, the speaker had the rather irksome duty of cleaning up about 100 square miles of the Croton watershed. The board of health of the state of New York had established numerous rules for the sanitary protection of watersheds from which public water supplies were obtained. These rules stated even the minimum distance between chicken coops and running streams. While these rules were very good, it was almost impossible to get the law department of the city of New York to enforce them.

From what Mr. Coffin tells us, the sanitary condition of the Croton watershed has been much improved in recent years, and every possible precaution appears to have been taken to prevent the city's water supply from being polluted.

Mr. Sherrerd has explained to us how Newark, New Jersey, is quietly buying up gradually the watershed from which it obtains its main supply of water. Boss Tweed, when he had control of the government of the city of New York, had some thought of buying up the whole Croton watershed, which contains about 350 square miles about the Old Croton Dam. The cost, however, even in those days when the value of land in the watershed was much less than now, was prohibitory. As Boss Tweed is only remembered

now as a corrupt politician, I wish to record here one of his actions which I think was very much to his credit. The late Gen. George S. Greene, who was chief engineer of the Croton aqueduct department when the Tweed ring obtained possession of the city government, told the speaker that Mr. Tweed sent for Benjamin S. Church, the resident engineer in charge of the old Croton aqueduct, and told him that he fully realized the great importance of the proper care of the Croton aqueduct to insure the health of the city of New York, and that he would not permit any political influence to interfere with the management of this great work. Mr. Church was permitted to retain all the assistants who were then employed on this work.

As regards the purchasing of a watershed, it will be in most cases impossible, on account of the great cost that would be involved. The city of Birmingham, England, acquired the watershed from which it derives its main water supply, but in this case the land involved is in the mountains and has little value. Even if a watershed is bought up by the community it supplies, one person who becomes sick with typhoid, or some similar sickness, is likely to cause an epidemic. Professor Mason tells us, in his book on *Water Supply*, that some years ago a workman who had contracted typhoid fever was sick in the mountains of Pennsylvania. It was winter at the time and all the slops from this sick person were thrown on the ground by the attendants. Cold does not destroy typhoid germs, and when warmer weather arrived and the snow melted, the germs got into little rivulets which gradually found their way into a big stream, from which Plymouth, about 20 miles further down stream pumped its water supply. About 1000 cases of typhoid fever resulted from the carelessness of the persons in charge of the sick person up in the mountains.

It seems to the speaker that in most cases it will be a great deal cheaper and safer to construct filters for purifying the water than to buy up a whole watershed and to patrol it. Of course, in the case of Newark, there may be some other object in view, such as creating a state park. As a general proposition, however, the best way to prevent pathogenic diseases from reaching a community is by mechanical or slow sand filtration.

ALEXANDER POTTER: Newark's policy of protecting its water supply by controlling the watershed has proved successful, the city having already purchased about 70 per cent of the Pequannock water-

shed. One cannot consider this problem long without raising the question: If this is proper for Newark, why is it not essential in every other city in the United States? If this question is answered in the affirmative, another question presents itself: Is it the most economic solution of the pure water problem?

In the Pequannock watershed the city of Newark established values which it was willing to pay for lands. Unless it is the only reasonable method of insuring safe water to a municipality the individual should not be asked or required to dispose of his land unwillingly, even admitting that Newark was willing to pay fair market value prices at the time of taking. If the owners would not accept these prices they saw the value of their property gradually depreciated by the destruction of adjoining houses and the elimination of the community value or unearned increment which they either paid for or helped to create. A property owner is not necessarily entitled to the increment in value due to improvements that the city might make, but he is certainly entitled to protection from the depreciation in value sure to follow a systematic program of the city for wholesale purchase of land to be put to such use as would inevitably depreciate adjoining land values.

This whole question is especially pertinent at the present time in view of the fact that Newark, for instance, has in course of preparation plans for the development of an additional watershed, namely, the Wanaque, not alone for Newark but also for other cities willing to join in the expense of its development. If Newark deems its practice in the Pequannock watershed hygienically sound it would naturally pursue the same policy in the Wanaque watershed, and consequently the development of this water supply from the Wanaque, if the same policy be adopted, would logically mean a systematic lowering of land values in this area to the detriment of the owner, either in present values or in future enhancement of value which it was perfectly legitimate for him to look forward to.

If Newark should adopt the same policy of purchase of the watershed of the Wanaque, it means one of two things: first, a vast increase in the cost of the project, if, for instance, anything like the same percentage of area is immediately purchased for the protection of the watershed, or second, if the ownership of this high percentage of the watershed is essential there is a potential danger from pollution until Newark can secure the same percentage of area that it has in the Pequannock watershed.

If it be admitted that the control of such large areas of watershed

ultimately is necessary, its purchase should be consummated not by the continuous process which inevitably reduces values, but by establishing at the present time the fair and just value of such lands in a manner prescribed by law for the acquirement of lands, giving the owners collectively ample opportunity to protect their rights and insist upon the payment of full market value rather than be forced to see the value of their property gradually depreciated and have no recourse against the destruction of values which some of them have labored so hard to create. If the ownership of such lands is deemed essential and the cities requiring them are required to pay for their exact value, which in fairness they should, then other methods, equally safe, of protecting and maintaining a pure supply of water may prove more advantageous and more economical without drawing from the market these vast tracts of splendid highland country which should be utilized, and ultimately will be required, to house the overflow population from nearby cities.

O. J. ORCHARD: I was particularly interested in Mr. Breitzke's remarks in reference to the success of persuasive measures rather than compulsion in securing abatement of nuisance. It was my good fortune at the time Mr. Breitzke began his work on the Jersey City watershed to be connected with the New Jersey state department of health and to have, under Dr. Fitz Randolph, the partial supervision of the inspectors. It was our custom, immediately upon receipt of report of pollution from one of the field men, to issue a formal notice requiring the abatement of the nuisance within ten days. The fact that the Phillipsburg case was then pending in court and had not been settled, placed the state department of health in such a position that these orders could not be enforced. The notices created a spirit of antagonism against our further efforts to secure abatement. The percentage of abatements from notices served was, I believe, somewhat less than 10.

About three years ago the procedure was adopted of sending a friendly letter to the owner of the polluting premises, calling his attention to the pollution; what it meant; the fact that it possibly endangered the lives of innocent persons; and the letter was followed up wherever possible with a personal visit by one of the field men. It is my recollection that the percentage of abatements secured at a far less expense than that involved by serving legal notices was

at least three, and I think fully four, times as large than when the ten-day notice was served.

ALLEN HAZEN: It has been suggested in connection with the pollution of watersheds by trains that the ballast in the railway track was itself an almost ideal sprinkling filter and that the dose is small and very well distributed.

MORRIS R. SHERRERD: Mr. Potter seems to lose sight of the fact that the ultimate purpose of the work the city of Newark is carrying on in its watersheds is not only to protect the consumers of the supply from these areas but also to convert this part of New Jersey into a great park. The latter purpose is no different from the creation of the Inter-State Park and the Palisades Park, for which the land was acquired in the manner followed by Newark.

In treating the Wanaque watershed it is proposed to build a trunk sewer to take care of the cities in the upper region of the river, and it is unlikely that a policy of acquiring land must be adopted here. Furthermore, as some of the cities which contemplate joining with Newark in the Wanaque project are now supplied with filtered water, they will doubtless desire to have the new supply filtered, not only to insure its purity but also its clearness, as their present supplies are clearer than the Wanaque.

ELECTROLYSIS[1]

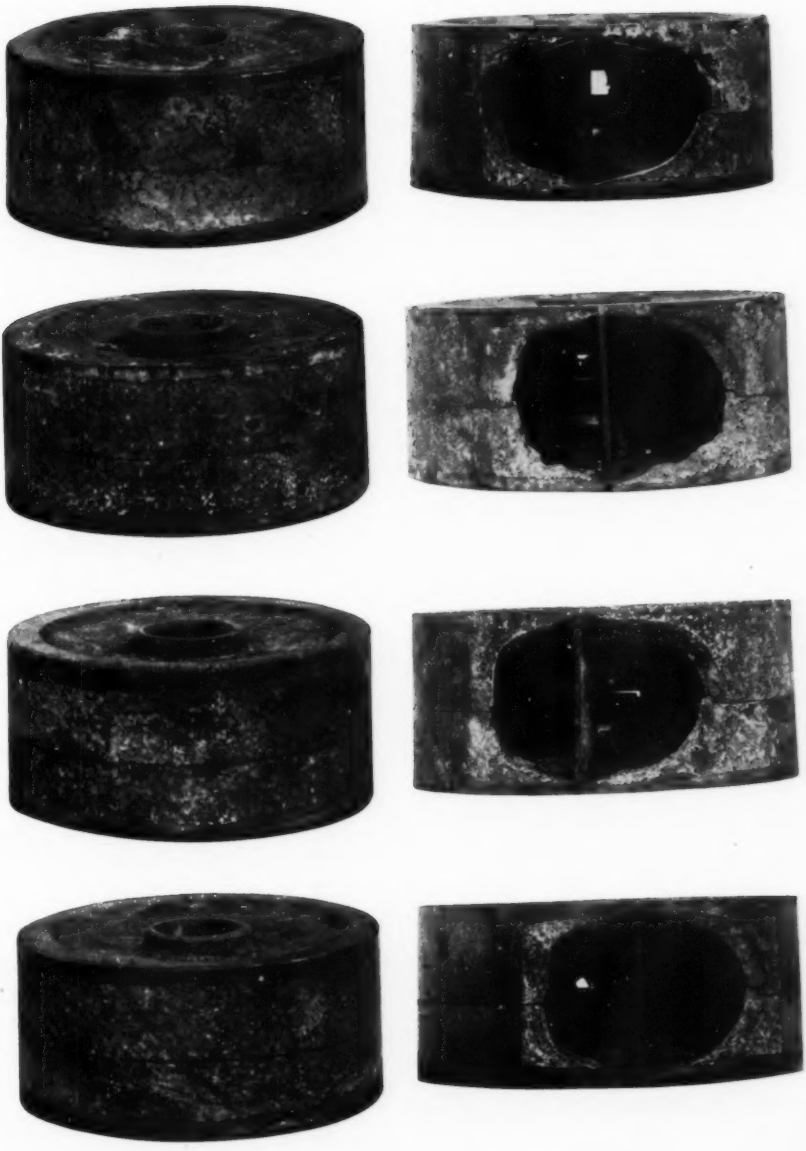
FRED B. NELSON: Tests and examinations have been recently made by the New York department of water supply on fifty meters which had been in continuous service for different periods of time, including five groups of ten each installed at five year intervals from 1895 to 1915. It may be of interest as having a possible bearing on the subject of electrolysis that on the disc chambers of those installed in 1900 a decomposition or pitting of the bronze chambers was found which was not present in any marked degree on those installed in 1895 nor on subsequent installations. The appearance of the decomposed metal suggested electrolytic action and analyses were made by the Central Testing Laboratory of the bronzes of the disc chambers affected and of one disc chamber not affected, from which the conclusion was drawn that the decomposition was due to a solution of the metal, the solution depending upon a number of factors, among which was the difference in composition or mechanical treatment and consequent differences of potential between adjacent portions of the meter.

The analyses showed quite marked differences of composition of the bronze even between the two halves of the individual disc chambers, these differences being least in the analyses of the unaffected chamber. The analyses also seemed to show that the bronzes higher in zinc and lead were the most susceptible to the corrosion. Analyses of the water being used through these meters showed no chemical differences that would account for the difference in corrosion.

This case of corrosion of bronzes is not cited as an instance of the usual action of electrolysis, as no indication or instance could be found to indicate that any stray electric currents existed or were leaving the bronze at the affected portions. It does, however, seem to illustrate a somewhat similar decomposition of the metal that may be caused by local galvanic action due to differences in composition or treatment of the adjacent bronzes used.

The appearance of the corroded disc chambers is shown in the accompanying illustration.

[1] A discussion of an informal address by Prof. Albert F. Ganz before the New York Section on December 20, 1916.



Appearance of Corroded Disc Chambers

H. B. MACHEN: A rather interesting case of what we believe was electrolysis recently appeared in the borough of The Bronx, New York City, where as you know the entire trolley system is of the single wire overhead type.

A leak was reported as at 132d Street near Lincoln Avenue. The department forces made the necessary excavations exposing the pipe and found that for a small portion of the pipe the iron had practically disappeared, leaving the carbon, the specific gravity of a section broken out about 6 inches square being about 2.

An examination was then made to determine if possible the cause of the local trouble and if possible prevent its recurrence. The pipe runs for about 800 feet through made ground which at the point where the pipe was exposed consisted of a fair grade of earthfill. The trench was dry, although but 600 feet from tidewater. The nearest elevated railroad and trolley lines were about 400 feet in a straight line. There was no difference of potential between the pipe and elevated railway except when a train was passing, and but very slight at that time. No differences could be detected at any time between the pipe and the trolley road. Examination of the pipe, which had been tested to 150 pounds at the foundry where manufactured and had been in service for a number of years at approximately 35 pounds pressure, showed that the trouble was confined to one length only. The total area affected was about 4 square feet toward one end of the length and indicated that the iron had been largely extracted, leaving carbon so soft that it marked paper easily. The pipe coating was in good condition in many places, having still the original gloss evident. To date it has not been possible to locate any source of current, either to or from the pipe, and still every fact available after the break disclosed the weak spot points to electrolysis as its cause.

As an illustration, the reverse of the case mentioned above and located in the same borough might be cited; the 36-inch main on Jerome Avenue where the pipe parallels a trolley line for over 5 miles. During a repair being made at night, just as the sleeve was being slipped over the end of the pipe, several sparks jumped the gap which appeared from the bank to be about 1 inch and which surely was over $\frac{1}{2}$ inch. This certainly indicated that the pipe was carrying current, and still we have had no trouble appear from electrolysis, which can have been going on for twenty years.

D. F. ATKINS: The department of water supply, gas and electricity of New York has received applications from electric railway companies for permission to bond their tracks to the water mains. This permission has been refused in every case, for there has been no proof offered that the city would gain anything by permitting such bonding, whereas the railway companies would thereby be relieved in a measure of the necessity of bonding their tracks so as to form a proper return circuit, which they should provide.

HARRY V. ALLEN: A water consumer in an outlying section of Brooklyn was required to pay a bill for water which was in part wasted on account of a leak in the pipe between the meter and the fixtures. The pipe had been corroded by electrolysis and he wished to recover for the loss he had sustained. A joint investigation made by the department of water supply, gas and electricity and by the public service commission indicated that the tracks in the neighborhood were poorly bonded and there was a flow of current from them to the sub-station through the intervening marshy ground. The tests indicated that the water mains were carrying heavy currents for some distance toward the sub-station, and that the currents then left the water mains and returned through the damp soil. The conditions were such that one of the lead service pipes transmitted currents which would theoretically eat away about 15 pounds of metal annually. The joint tests were suspended owing to representations made before the commission questioning its jurisdiction to order circuit changes on the part of the company, which were necessary to a conclusive test.

NICHOLAS S. HILL, JR.: In 1895 we were installing in Baltimore near an electric railway power station an underground conduit system for telephone and telegraph cables. We laid lead-covered cables with their ends tied together but in three weeks time the lead covering was entirely gone. The cables were laid in a weak solution of sewage and everything was favorable for corrosion. The action was so rapid that it was necessary to make an electrical survey at once. We did not know then as much about electrolysis as we do now, and the first thing we thought of doing was to connect the cables with the busbar of the power station. When this was done we found that we were returning about 1800 out of the 2800 amperes supplied by the station.

There is but one solution of the problem of electrolysis. That is insulation of the rails so far as possible and increase in the conductivity of the track circuit back to the station within economical limits. It is unwise to attempt to force methods upon the railways which are so expensive that they are prohibitive. I have felt, and this opinion is substantiated by the decisions in the suits brought at Peoria, Indianapolis, Dayton and elsewhere, that we gain nothing by bringing suits which attempt to force a particular kind of construction on the railways, because when the water department or water company appeals to the courts on such a basis, the construction demanded is such that it is easy to prove to the courts that such a requirement amounts to confiscation and the courts are loath to do anything which has even the appearance of confiscation.

The attitude of this association in the matter of electrolysis should be one of coöperation and arbitration rather than one of coercion. If damage is done, we have the same methods of recovery that any person has by bringing suit to force the offender to pay for the damage he actually does, but I do not believe we can profitably use the courts in any other way than the recovery for damage sustained. We are working in the streets in conjunction with other public utilities and we all have equal rights in them. What we should do is to coöperate with engineers who are better equipped by training to attack the problem of electrolysis and to formulate with them remedial measures and standards of construction which will reduce this trouble to a minimum.

D. W. FRENCH: I do not think the experience the Hackensack water company has had from electrolysis is unlike that of any other water company. We have usually found that such trouble as we had was due to poor rail bonding, and when voltmeter readings exposed what was going on and the matter called to the attention of the railway officials, they were generally remedied. A number of lead service mains have been completely ruined by stray currents and these services have been replaced by the railway company at their expense.

HERMANN ROSENTRETER: We have found an unusual instance of the straying of return currents in New Jersey. There is an electric railway running southwesterly from Paterson and paralleled by a 42-inch main supplying Jersey City. A 42- and a 48-inch main

supplying Newark intersects the railway and runs directly away from the station supplying current for the cars. A leak in the Newark mains was reported in a swamp about 3½ miles from the railway crossing. Investigation showed about 20 amperes flowing in the mains at that place and several miles farther from the power station we found a current of 2 amperes. In order to be sure that the current came from the railway, measurements were made one night before and after the road was shut down. When the car service stopped the current flowing out over the mains stopped and a small current flowing toward the Paterson power station was observed. In other words, current from the station strayed 11 miles away from the railway on which it was supposed to remain.

ALEXANDER POTTER: At San Antonio, Texas, we found the service pipes pitted with what appeared to be electrolytic corrosion. This appeared in all parts of the city and an experiment in the way of protection is now being made. This is to cover the services with tile pipe, which has not been in use long enough to prove its usefulness.

F. T. KEMBLE: Our troubles with electrolysis in New Rochelle are pretty much the same as those of everybody else, though the points at which it occurs are rather localized. But there is one condition that probably differs from other plants that may be of interest to you. Along the Long Island Sound shore section much of the trolley return current is carried over the tracks of the New Haven Railroad, who have their tracks bonded directly to the busbar in the power house of the trolley company. Professor Ganz has made a study of our section and is entirely familiar with this condition. As showing one of the channels through which the current has traveled, we have on two occasions found a 1-inch piston meter, which was set on the railroad company's own connection near its tank house, have its piston so warped that the meter ceased to register. After the second occurrence, which was after an interval of about six weeks, we placed the meter in a vault close to our main, a distance of less than 200 feet from the original location, and since then we have had no further trouble with it.

ALLEN HAZEN: It is well to bear in mind that punk metal is not necessarily due to electrolysis. Iron pipe has been found in a punky condition miles away from any electric railway and where

there was no possibility of its being due to electrolysis. In such cases it is doubtless the result of the chemical action of the soil. The alkali in certain western soils seems to have a powerful action of this kind. Several years ago, in building a steel water pipe, at each crossing of an electric railway, the pipe was covered with building paper in successive layers, each of which was heavily coated with tar. This treatment was inexpensive and seems to have been in line with the treatment suggested by Professor Ganz.

PROF. ALBERT F. GANZ: It is not generally possible to satisfactorily answer questions in regard to electrolysis unless complete information stating all of the conditions can be given. It is generally difficult to obtain such complete information from inquiries made in connection with discussions before meetings like this.

I am glad to hear that the department of water supply, gas and electricity of New York City has refused to permit the electric railway companies to bond their water mains to the railway tracks. Such permission should not be granted because the bonding of water pipes to the tracks makes the water piping system part of the railway return circuit, and almost always makes the piping system carry very large currents, and these become an increasing source of serious danger. Mr. Nicholas S. Hill has well illustrated by his experience in Baltimore that it is of great advantage to railway companies to connect underground structures to their railway return circuit, as they thereby obtain the use of these underground structures for the return of current. He has also shown that these structures are made to carry very large currents by such connections.

In regard to the attempt in San Antonio to stop electrolysis by encasing the water services in tile pipes, I beg to say that this arrangement can only succeed if the joints in the tile pipe and the connection to the water service are made waterproof, so that the space between the service pipe and the tile pipe does not fill with water. If this space does fill with water, then current may continue to flow from the service pipe to the water and produce corresponding corrosion of the service pipe by electrolysis. I would suggest as an improvement that the space be filled with a compound like pitch.

The heating of the 2-inch water meter by current from the New York, New Haven and Hartford Railroad in New Rochelle is very interesting, and I am sorry that I have not more details in regard

to this very important observation. Mr. Hazen's remarks emphasize the fact that it is not possible to tell from the appearance of a corroded pipe alone whether it has suffered from electrolysis or from purely chemical action. To determine this, requires electrical measurements to see whether current is leaving the pipe which could produce electrolysis.

In regard to lead service pipes which are reported to be destroyed by electrolysis from current reaching the water service pipe from the gas main by way of the house service connections, I would suggest that if this is the path of the current which damages the water service pipe, the trouble can be remedied by inserting an insulating joint in the water service directly inside of the cellar wall, thereby preventing the flow of the damaging current out on the water service pipe. If, on the other hand, the current flows from the water main to the water service pipe, then an insulating joint would have to be inserted in the water service pipe close to the main. A safe precaution would be to insert an insulating joint in the water service pipe both close to the main and directly inside of the building.

In regard to the question of grounding transformer secondaries to water pipes, I would say that there is absolutely no danger in permitting such connections to be made. Transformers operate with alternating current, and the object of grounding the secondaries of transformers is to serve as a safety measure to prevent the possibility of persons obtaining a high voltage shock. Under normal operating conditions there is no flow of current to the water pipe from such transformer connections, and in my opinion such conections can be safely permitted.

SOME OBSERVATIONS UPON PUBLIC REGULATION OF WATER WORKS[1]

By Leonard Metcalf

Public utility activity did not begin until after the middle of the last century—in the water works field early in the eighties; in the electrical, gas and telephone fields in the early nineties; and in the railroad field at an earlier time, though the greatest expansion has occurred therein since 1890.

This rapid expansion necessitated a change in the earlier policy of building betterments in considerable measure out of the earnings of the corporation, to the present method of building from the proceeds of large bond issues, which throw the burden of payment in greater degree upon the future users of the service than did the earlier practice. This change brought about serious abuses in the obtaining of franchises and over-capitalization of corporate property, during the first decade of this century. The natural result followed in an attempt to control the activities of the corporation, evidenced by the establishment of the Wisconsin railroad commission in 1905, the New York public service commission in 1907, the California commission in 1911, and the Pennsylvania commission in 1913, the Indiana public utilities commission in 1913, although the Massachusetts commission had been in operation for many years before the establishment of any of these.

There followed a period of corporation baiting and the passage of many laws making the operation of the corporations, and more particularly the maintenance of good efficiency and esprit de corps, very difficult to them. The railroads particularly have continued to suffer acutely, as evidenced by the statement last year of Mr. Howard Elliott, formerly president of the Northern Pacific Railroad, now chairman of the board of directors of the New York, New Haven & Hartford Railroad before the annual meeting of the Chambers of Commerce of the United States:

[1] Presented before the joint convention of the Iowa and Illinois Sections at Moline, Illinois, October 11, 1916.

Whatever the reasons for the malady of the railroads, two facts stand out prominently in the history of the railroads of the United States for the year 1915; one is that less mileage was built in that year than in any year since 1864. There have been only three years since 1848 that there was a smaller mileage of new railway constructed than in 1915. The other fact has to do with the amount of railway mileage in the hands of receivers in 1915. With only one exception, 1893, was the mileage that entered into the hands of receivers larger than last year and 1893 was a panic year,

and this was in spite of the good crops of recent years and great activity in certain sections of the country due to war orders.

Further evidence of these influences is to be found in the recent advocacy by President Wilson, and enactment by Congress, of the Adamson railway bill, granting ten hours pay for eight hours work to railway engineers, conductors and others, subject to review hereafter by a commission appointed by the president, and to the possible increase in rates if economies to be effected by the railroads shall not otherwise offset this arbitrary increase in operating expenses.

Similar experience has developed in the Far West, in the East and Middle West. There are many similar examples which are known to you and to which, therefore, no reference is made.

But today there are already evidences of better conditions and that the pendulum is swinging again toward its middle position. The management of our great public utilities is cleaner and better for the agitation. The rights of the public are today recognized quite as clearly as are those of the corporation, indeed a spirit of toleration and effort to court the favor of the public has been developed on the part of the corporations, probably to a greater degree, than on the part of the public service commissioners and the public, for it is an unfortunate fact that some of the public representatives still appear to regard themselves as advocates of the public interest rather than as impartial judges—between the interests of the public and the corporation—and it is unfortunately still true, and is likely to continue to be true under American political conditions, that political pressure is felt by the commissions as well as by the corporations. Here, too, conditions are improved, however, over those of a decade ago.

In the view that regulation by commission is probably the best solution of current issues between the corporations and the public, it may be of interest to review the present outlook, in its broader aspect, after a decade or more of commission control.

PUBLIC CONTROL

What do we mean by control of the public utilities by public service commission? The effort to so regulate the conditions of service and the financial return as to assure the public good service at fair price, and to the corporation a reasonable return upon the fair value of its property devoted to public use.

This involves the determination by the controlling or regulating body of, first, the fair value of the property; and second, the equitable rate of return upon it commensurate with the hazard involved by the business.

BASIS OF COMMISSION CONTROL

The prescribed or existing conditions must be such as to attract capital to the rendering of these services, which the public, for one reason or another, has not cared to undertake for itself. In this connection a clear distinction must be made between natural monopolies such as water works, electric or gas plants, and the competitive enterprises, such as the railroads.

Two methods of operation are possible. First, the guaranteeing to the corporation of fair return upon its actual investment, with the lower rate of return commensurate with this guarantee; second, forcing the company to bear the hazard incident to the investment and giving to it a higher rate of return commensurate with this hazard and with the fair value of the property devoted to the service of the public.

The higher courts have constantly adhered to the second principle, ruling that original cost was of significance but not necessarily of controlling importance; that reproduction cost as of date of valuation was of importance, particularly in the case of old properties, and that consideration should be given to the value of the securities, to the worth of the service to the consumer, and to any other matters which might seem to have probative force in fixing value.

The controlling commissions have unfortunately not always followed the precedent of the courts, but have sometimes tended strongly toward the measurement of values practically by original cost, even excluding from the latter those elements of cost carried by the operating account, regardless of the question as to whether a fair return was earned contemporaneously with the payment of these costs; have sometimes excluded certain elements of so-called increments of value recognized by the courts; and have attempted to make the corporation carry the burden of the hazard of the business on an allowed rate of return commensurate with an implied guarantee, instead of with the actual hazards of the business.

REGULATION VS. OPERATION BY PUBLIC UTILITY COMMISSION

There has been ground for anxiety lest the commissions should go so far as to attempt to dictate policies rather than simply to control or limit the activities of the corporations, though in the main, the commissions have wisely limited themselves to the functions of a regulating body, upon the theory that it is safer to leave to the executive officers of the corporations, who are accountable not only to the owners of the property but also to the regulating commission, the determination of policies of operation; leaving the commission to sit in review upon the results obtained under them, rather than for the commission to determine those policies. If the commission is to dictate operating policies it must, in all fairness, assume full responsibility for them and relieve the corporation management of the hazard element involved, thus in effect guaranteeing revenue and operating conditions to the corporations, as would ultimately be necessary under such a theory of public administration.

The public has clearly manifested its preference for *regulation* by commission of corporately operated public utility property, rather than public or commission *operation* of such public utility properties, under the past and present conditions prevailing, and the future conditions likely to develop in the United States. Thoughtful observers see grave danger in the extension of the functions of the public service commmission to the determination of the details of operating policies and practices, as well as to the broad problems of character of service, fair return, and equitable distribution of the burden of rates, unless the commission can be divorced

from politics and be given *far* greater financial support and unless the hazard of operation be assumed by the public, all of which will certainly involve a serious change in policy and a final cost of service to the public likely to be *substantially* greater than that under private operation and public utility commission control of such properties.

REQUIREMENTS OF VALUATION

The fair valuation of large properties, having diversity of interests, is not a simple but a highly complex matter. It is dependent upon:

1. Experience in the design, estimate of cost, construction, and operation of such properties.
2. Imagination, tempered by judgment.
3. Intellectual honesty and logical mental habits, the ability to determine causes and their effects, and the relative importance of different facts.
4. Knowledge of men, ability to work with them, and to be able to draw out information.
5. Technical knowledge and skill.
6. Character and judicial temperament.

Think for a moment of the steps in valuation of the property of public utilities. The trained mind does not think in formulas but goes unconsciously straight to the heart of the matter; it determines and faces the facts. If the facts be stubborn and do not fit pre-conceived theories, it reconstructs its theories but never blinks at the facts. Intellectual honesty and good morals demand this.

First, the imagination is called into play, picturing the historic conditions and the probable present day conditions under which the works have been or might be built and developed, in accord with available records of the past and the probable present conditions incident to the reproduction of the property.

Then the inventory of the property is prepared, requiring extreme care and technical knowledge of design and methods of construction.

Next the unit prices and overhead costs are applied to the inventoried quantities, involving thorough knowledge of cost, methods of construction, and careful study of local conditions and limita-

tions, if the valuation is to be fair and not purely academic. It is here that the evaluator is at the greatest disadvantage if he has not had breadth of actual experience in construction, for he is liable otherwise to seriously under-estimate the difficulties and hazards to be encountered, and the collateral or incidental costs involved, as every man who has had breadth of construction experience in large corporate works, or who, perchance, has built himself a house, appreciates full well.

Then comes the much more difficult determination of the so-called "intangible," though real, elements of value, the franchise, water rights, cost of developing the business, and other similar elements: a study of the financial elements involved; and so the final determination of fair value of the property and fair rate of return to be allowed upon it, in the light of all the pertinent facts.

As the construction and building up of such properties involves the work and coöperation of the promoter, the financier, the engineer, and the operator, for the development of the highest efficiency and accomplishment of the best results, so the valuation of the property at a later day involves, on the part of the evaluator, the qualities heretofore mentioned, coupled with much hard work, discrimination, open mindedness and judicial viewpoint. If the evaluator plays the roll of advocate instead of judge and limits himself always to developing the viewpoint of one of the parties at issue, whether the public or the corporate, he is likely soon to acquire mental bias. At the upper end of the line we have the true expert, or man of experience in the particular subject under discussion, who strives to develop the facts honestly and with open mind, and then to interpret them judicially. At the other end of the line, we have the equivocator, the smart Alec and the political trimmer. The former is a man of character, most valuable to the public; the latter a mere breeder of discontent and further trouble.

Members of regulating commissions and their engineering staffs are open to the same dangers in the field of valuation as are financiers, engineers, and operators, who testify for the public or for the corporation in valuation or rate proceedings. The external pressure brought to bear upon them politically, through the newspapers, or by individuals, is quite as dangerous as that of the officers or employees of the corporation, and the need of sturdy independence of character is equally essential.

Injustice done to the public or to the corporation does not end with the act of the commission, any more than with that of the corporation; economic conditions ultimately control, and the burden of unfair restriction is most likely, ultimately, to fall upon the shoulders of the public, as it fairly should, inasmuch as the public is responsible for the character of the commission control.

RESULTS OF COMMISSION CONTROL

The results of commission control reflect in general the attitude of the public and the body politic, the breadth or narrowness of view, the experience or lack of experience, the force and independence of character or yielding to expediency and political pressure of the commissioners themselves, the frankness, candor and honesty of the corporation officials or the reverse.

The commissions have in certain respects rendered very important service; they have brought about a more wholesome publicity, have prevented the abuse of serious inflation of values, in some cases have tended to stabilize values and give greater security to property, and they have compelled a juster recognition by the corporation of its obligations to the public; in some other respects they have not infrequently failed, to wit, in under-estimating the value of public utility properties, in arrogating to the public enhancements in value or elements of value granted to the corporation as well as to the individual by the highest court, and in prescribing or limiting rates to a return which shows no substantial margin of profit. When they have failed, it has generally been due to lack of breadth of experience and familiarity with such problems, but unfortunately, also, sometimes due perhaps to political pressure or ambition and the playing of the rôle of public advocate rather than that of judge. While the extenuating circumstances have often been great, the public responsibility large, the results have been none the less injurious to or subversive of the highest and most efficient standard of service by the corporation.

There can be no doubt that the intelligent and fair-minded public is far more interested in having good, prompt, and up-to-date service at a price yielding a fair or even liberal profit to the corporation rendering it, than it is in the slight reduction in cost of service to the public which may mark the turning point between a fair and an adequate profit, or between profit and loss to the company.

Thus in the water works field who can doubt what would be the answer of the average man were he asked, "Would you rather have your present inadequate service or pay 20 cents per month more for your family service, which is equivalent to 40 cents more per capita per year for a thoroughly good service?" And yet this 20 cents per month increase would mean 1 per cent more or less increase in annual revenue or return to the corporation and might well mark the difference between good credit and bad. Moreover it is to be noted that the corporation is twice penalized if the commission fails to permit adequate earnings, first, in the reduction of revenue and hence return upon the fair value of the property, and second, by its resulting inability to borrow money so closely to the market as when it *is* earning a return which shows profit, for the market exacts interest rates commensurate with hazard, and with the available protective margin of earnings. Thus, for instance, the corporation may borrow money upon its bonds at a 5 per cent rate, if the bonds cover but one-half to two-thirds of its property value; at 6 per cent or more, if they cover three-fourths to seven-eighths of its value; and at yet higher rates, if the bonds equal the property value, or it may not be able to market its bonds at all under the latter conditions. The allowing of a fair margin of profit is not only *necessary* but *advantageous* to the public.

It is the concensus of opinion that the commissions have rarely given tangible reward to superior management, that they have found no substitute for the incentive of extra profit and that they have too often *limited* or *reduced* the revenue upon the property to a return which shows no profit and no inducement to superior management, with the result of a declining service, a declining market value of the corporation's securities, or even of loss of market, and final inability to borrow at previous rates. Such conditions cannot be justified by any temporary saving in rates to the public, or to the individual, for the ultimate cost of the service is actually increased by such drastic treatment and the day of reckoning always comes.

No individual, no commission, no court can long dominate money rates. Economic conditions ultimately control, and the lowest rates follow the fairest and most stable conditions of service.

The unfair claims by corporations of enormous franchise and intangible property values has brought its own reward, great shrinkage in these claimed-values. The investing public, as well as the court, has discounted these claims.

On the other hand, the failure of some of the commissions to give adequate recognition to the difference in value of the property *with* established business as compared with one *without* it, and to permit rates of return showing *profit* as well as interest allowance, is also being discredited. The business man, the operator, and the financier, have always recognized this substantial enhancement in value of the property growing out of the developed business; the investor has always willingly paid for it; the highest court has long admitted it. Broadly speaking it is only the commissions that have failed to make *adequate* financial allowance for it. Moreover they have often failed to permit the earning of revenues which would show a return, including interest *and* profit.

Examples of the evil results of unreasonable regulation are not lacking; note the present selling price of and return upon the stock of the Boston Elevated Railway, long under state commission control, the stock of which has been issued and sold for many years past at rates prescribed by the commission, much of it above 125, now selling at below 80, and the corporation obliged to plead for higher return to enable it to borrow funds necessary for extension and betterment of the property.

The Denver Union Water Company, victorious in its recent rates suit before the federal court, which declared confiscatory the city ordinance reducing rates 20 per cent, which ordinance was based presumably upon the public utility commission's determination of the value of the property, which value was substantially doubled by the federal court.

The Spring Valley Water Company suits of 1903 and 1905 won by the company, and those of the period of 1908–1915 recently concluded after ten months of nearly continuous trial, now awaiting the decision of the federal court for the District of Northern California. While this company was not until recently under the jurisdiction of the California railroad commission its rates have been subject to annual review and determination by the city's representative, the board of supervisors.

With the Des Moines Water Company litigation and decision you are familiar.

The Richmond decision of the Indiana commission, subsequently revised by the commission itself, and the Terre Haute decision, both reducing the returns to a point adverse to public policy, as evidenced

by the commission's own subsequent action in raising the revenue first allowed by it to Richmond, on the one hand, and on the other the present difficulty in which the Terre Haute Company finds itself financially in being unable to raise money for necessary construction and being compelled to suspend the payment of dividends to raise the needed capital. You gentlemen know Dow R. Gwinn, president of the Terre Haute Water Works. Water works men and engineers the country over know and respect him. The commission itself admits his good management and fair-minded point of view. Yet the commission has taken action which has seriously endangered the high character of the service which this corporation can render to the public. It is but fair to admit that the effect of the reduction in rates by the commission was rendered more burdensome by the contemporaneous change by the company from a flat rate to a meter basis of selling water. But this only gives further evidence of the hazard which the commission took in fixing too low a minimum monthly meter rate, an unnecessary hazard as the commission could have fixed a tentative monthly minimum rate, to make absolutely safe this transition from flat to metered service basis, reducing this minimum by progressive steps as the actual developments might have made possible. The control of the situation was and still is in the hands of the commission and therefore it may fairly be held responsible for the present deplorable situation. It is believed that the commission itself deeply regrets the situations which have developed both at Richmond and at Terre Haute, and these cases are specifically cited here merely to bring home the lesson that it is not to the advantage, indeed, it is to the distinct disadvantage, of the public to have the commission rule so closely in its decisions as to incur such hazards. The good faith of the commission is not here challenged, merely the wisdom of its action from a public point of view.

Has not the reported "saving to the public" been derived at the expense of the character of service possible in the long run, and of fairness to the company? At least, the present financial standing of the company has been impaired and the attractiveness of investment in such properties in Indiana reduced. Time will show whether the action is not more far-reaching and of greater import as a problem *in policy* in control. It seems highly probable that a more liberal policy would have better served the public and the state.

The cost of litigation resulting from the commission's extreme action is also to be borne in mind, burdensome as it always is of necessity. The commission can not play the public advocate and then say that the corporations are safe in their hands. The action of the public at Denver, adjudged unfair by the federal court, has involved an unnecessary aggregate cost of upwards of $500,000 in expenses to the parties at issue. The San Francisco action probably cost $750,000. The expenses of inventory, valuation and litigation rarely are less than $25,000, even in the smaller cities. Such large expenditures yield better returns in structures than in legal battles. Moreover it is very important to note that it is the public which ultimately has to pay these costs. As the federal court has said in a recent California water works rate decision, though the expenses of such suits be excluded in determining the question of confiscation, they have unfortunately been incurred so frequently of late that they must be given consideration in fixing the fair return. The fair return must be raised to accord with the increased hazard of having to contest such suits and to meet the costs involved. The judge was a man of broad experience as well as a fine jurist, and he knew that this was the view of the business world and of common sense. Therefore, the commissions should be prudent and conservative in action in the public interest.

THE REMEDY

On the part of the public, better compensation, longer tenure of office and freedom from political control of the Commissions and their staffs.

On the part of the commissions, greater liberality in their determinations of value and the fair rate of return, a return which will *in fact* recognize the necessity of giving *profit* as well as more interest upon investment, and which shall encourage and offer substantial inducement to and adequate compensation for superior management: conservatism in applying new rate schedules, making the changes step by step, and fixing sage tentative minimum monthly meter rates for the transition from flat to metered rate basis of selling water, lest the prescribed rates fail to yield the reduced return fixed by the commission: and finally a sound and fearless stand on the use of meters to their economic limit.

On the part of the corporations candor and frankness in their relations with the commissions, more careful accounting and record of property and costs.

Take the commissions into your confidence, rather than hold them at arm's length. Be reasonable and recognize the difficulties of their position and that of their staffs. Play fair and let the facts prove your case, and then fight for fair treatment, if injustice be done. Under such conditions only, possible though difficult of attainment, can a permanent solution of vexatious present problems be reached.

THE SIOUX CITY BOOSTER STATION[1]

By Philip Carlin

The city of Sioux City, the second city in Iowa in respect to population, has a municipally owned water works, the construction of which was begun in October, 1884. On January 12, 1885, the 12 miles of water mains were flushed out and filled, and a 1,500,000 gallon reservoir was added during the year. By January 1, 1886, the income from the rentals was sufficient to meet operating expenses. The bonded debt of the works at this date was $133,390.89. This debt with all other obligations has been wiped out and the plant today is free from debt. As the population increased extensions were added until the length of mains has become 101 miles, ranging from 4-inch to 30-inch. In addition to this some forty miles of smaller pipe have been laid for temporary use.

The water supply is taken from drilled wells from 6 to 26 inches in size.

The pumping machinery consists of a vertical Holly triple expansion 6,000,000-gallon pump, a Snow cross-compound pump of 4,000,000 gallons capacity, two Deane compound condensing 2,500,000-gallon pumps, one American Well Works motor-driven 2,000,000-gallon turbine pump, and two Gould triplex 500,000-gallon pumps. The last are located at Leeds, a suburb, and operated separately from the city proper. The four pumping stations are in good condition and at no time in the last few years has there been any difficulty in furnishing an ample supply of good water with adequate pressures in the congested districts. At the present time the pressure is quite satisfactory in the higher districts. The average pressure maintained in the business district ranges from 90 to 110 pounds per square inch.

The motor-driven turbine pump has been furnishing the city 2,000,000 gallons per day from a 26 inch well, 315 feet deep, about two miles from the center of population. A duplicate installation has been

[1]Read at a joint session of the Illinois and Iowa Sections at Moline, Ill., October 10, 1916.

contracted for and will be in operation in July, 1917. The water taken from these wells is delivered through two 24-inch mains to two reinforced concrete reservoirs at an elevation of 258 feet above datum. The capacity of these two reservoirs is 7,500,000 gallons to the overflow. These reservoirs furnish water to the city through two 24-inch supply mains.

Some eighteen or twenty years ago the city council decided to extend the water mains to Morningside, a beautiful suburb of the city which is now experiencing a rapid growth. A growing city is destined at some time to be perplexed with complaints that the water pressure in the distributing system is not sufficient, notwithstanding the fact that the quantity of water is ample to supply all needs. Such complaints come sooner to cities with a rapid growth, as was the case at Sioux City, whose population has increased from 33,000 at the time mentioned above to 63,000 at the present writing. When cities grow, the pipe lines must of necessity be extended, and as the draft, length of mains and velocity increase the pressures will naturally decrease. It was decided by the council to lay a 10-inch main a distance of about four miles into the center of this suburb with branch lines of 6 inch pipe extended to the outskirts. The elevation along the center of this district will average 164 to 170 feet above datum. The elevation at the reservoirs being 264 feet, you will readily see that the pressures at these points would be very light. Recording gauges were placed on fire hydrants in the center of this district, which showed pressures of 22 to 31 pounds per square inch. After deciding that such pressures were not sufficient to meet the requirements in case of large fires, the water officials began devising some means whereby the difficulty could be remedied. A consulting engineer was employed, who planned to install a sub-station about midway between the city proper and the extreme end of Morningside, at an elevation of 115 feet above city datum. Water was to be pumped from a 10-inch main into a steel stand pipe located 120 feet above the highest point in Morningside. This would be at an elevation of 260 to 270 feet above city datum. This plan seemed rather attractive, but its cost was an objection. The city finally abandoned this plan, and the following plan was adopted, and is now in use.

A sub-station is located at Helen and Dodge Streets at an elevation of 115 feet above city datum, where the static pressure is 50 pounds to the square inch. There were installed three two-stage

Buffalo centrifugal pumps with a capacity of 370 gallons each per minute, pumping against a head of 215 feet. When drawing at the rate of 1,000,000 gallons per day, the pressure will not drop below 15 pounds in the suction main. One of these pumps is used as a relay and is operated only in case of a large fire. These pumps are connected to a header, and the header connected to a 6 by 23-foot steel compression tank.

The pumps are motor driven and direct connected to three 40-horse power 500-volt motors making 1200 revolutions per minute. The power to operate these motors is furnished by the Sioux City Gas and Electric Company, and the Sioux City Service Company, connections to different lines being so arranged that if an accident should occur to one of them, power can be obtained from the other by manipulating the switches. A Cutler-Hammer regulator was installed by which the pumps are automatically started when the pressure in the discharge pipe falls below 50 pounds pressure, and are automatically stopped when the pressure reaches 100 to 105 pounds.

Water is pumped through a 10-inch discharge main to a distance of 3½ miles. The results are just the same as if we were pumping into a standpipe. When the standpipe is full, you stop pumping, and when the water is drawn down to a certain point, the pumps will automatically start pumping again. A 10-inch by-pass was connected to the 10-inch supply main with a 10-inch check valve placed on the line to Morningside, so that as soon as the pumps are started, the pressure is raised on the discharge side of the pumps. immediately closing the check and pumping under heavier pressure. This by-pass can be used in case the pumps are down for repairs.

On account of the rapid growth of this section of the city, which now has 1980 services, the 10-inch main has been taxed to its fullest capacity during the last year. The writer prepared plans for and has just finished laying a 12-inch main to this booster station to reinforce the present supply main. Pressure tests at fire hydrants at a distance of about one mile from this station, using four streams from 2½-inch hydrant connections with 1-inch nozzles, showed 65 to 75 pounds pressure at the nozzle with vertical streams thrown to a height of 84 to 90 feet. The compression tank, which takes the place of a tower and tank, is provided with a small motor-driven air compressor, by means of which the tank is at all times kept more than half full of compressed air, forming an expansive cushion which

maintains the water pressure between the time of stopping and starting of the pumps.

The mechanical efficiency of the pumps was 75 per cent at the time of installation. Current is furnished at the flat rate of 2 cents per kilowatt-hour. The average monthly consumption of current is from 3000 to 3150 kilowatt-hours, while the bills for same range from $42 to $64 per month.

This booster plant was designed by F. W. Cappelen, of Minneapolis, consulting engineer, and installed during the term of office of G. B. Healy, commissioner of parks and public property. The present commissioner, J. M. Lewis, has recently ordered plans for the enlargement of the plant following along the same general lines of the original installation. The performance of the plant has been very satisfactory during the five years of continuous service through which it has passed.

EXPERIENCE IN HANDLING BAD WATER COMPLAINTS AND LABORATORY CONTROL[1]

By Earl T. Kirkpatrick

"The water that you are furnishing your consumers is dangerous. A neighbor of mine has typhoid fever contracted from the use of this water, and we are afraid to use it without first boiling it." These anxious words came over the telephone to the superintendent of a certain water company. To all those engaged in the management of water works they have doubtless become familiar and disagreeable words. Disagreeable not because they are true, for ninety-nine times out of a hundred they come from the users of water from dead ends where the water has acquired a slight taste or odor from some harmless microscopic growth or mineral and contains nothing in the way of pathogenic organisms, but disagreeable because of their daily insistent repetition, and the lack of the proper means for conveying to the consumer the facts concerning the true condition of the water. True the superintendent may order the dead end blown off, but this at best is only a temporary remedy and in three or four weeks he will again become the recipient of a similar alarmed message from the same neighborhood.

The Des Moines Water Company, in common with other water systems, has for a number of years had this problem to contend with. It was felt that a great amount of water was wasted on unnecessary blow-offs, and even when they were necessary nothing was done to remove permanently the consumer's suspicion of the water. A plan was therefore devised which had as its twofold aim the curtailment of this waste water and the education of its public in some matters relating to the sanitation of water. This plan is, in brief, as follows.

When a bad water complaint comes in, being as it is a question of the sanitary condition of the water, it is referred to the laboratory. Here it is given a serial number and filed in the "complaint

[1]Read at a joint meeting of the Iowa and Illinois Sections at Moline, Illinois, on October 10, 1916.

book" together with the date, name and address and cause for the complaint, and the consumer is told that an early call will be made for the purpose of inspecting the water.

This serial number is then transferred to a map of the company's distribution system at the location of the complaint. This map together with the complaint numbers makes an excellent record of the complaints. It shows graphically the location from which the complaints are coming and makes a simple method for the routing of the trips on which the subsequent calls are made.

The call is then made upon the complaining consumer and the water examined. With the Des Moines water the majority of the complaints arise from dissolved iron. If there is only a slight amount of this iron present the usual complaint is that the water has a strange taste. In this case it is explained to the consumer that this taste is not due to the presence of disease-producing organisms or anything that would cause physical disorder, but is merely the taste of a small amount of iron which is considered beneficial to the human system. This explanation is ordinarily taken at its face value by the consumer and the main is not blown off.

If, however, there is a greater amount of iron present, the usual complaint will be that the water is unfit for laundry purposes. If on examination this statement is found to be true the end of the main is blown off. Sometimes on such occasions it is found that there is some sediment present. When this is the case this content is estimated by means of the Whipple sediment test. This consists in forcing a measured amount of the water, usually a quart, through a cotton felt disc which retains upon its surface the sediment contained in the water. The disc is taken to the laboratory, dried and mounted in a book making a graphic record of this condition of the water.

Another class of complaint comes from the citizen whose family is about to be taken from him by typhoid fever, resulting from the use of the grossly polluted city water. True they do not have the fever at the time of the complaint but the water has an odor and a taste which the complainant believes to have come from some pollution and so he regards the water as likely to contain the germs of typhoid fever. It is not surprising that this person should think that such a water contains disease germs. All his life he has heard that typhoid fever comes from the use of infected water and his "common sense" tells him that an unfamiliar odor in the water denotes in-

fection. In dealing with such complainants we endeavor to show them that they cannot rely absolutely upon the means which they have at hand to determine whether or not a water is fit to use. We explain if we can the cause for the unfamiliar odor and explain its perfect harmlessness. We also explain something of the purification system and endeavor to show the impossibility of typhoid being present. A sample is then taken for bacteriological examination. When this examination is finished we follow up our first call with a second showing the results of the examination and what they signify, and *do not drop the complaint until the consumer is convinced that the water is pure.* Almost invariably the consumer appreciates the efforts which the department has made in the investigation of his complaint and is willing to accept our statements concerning the purity of the water.

Before concluding any of these calls we try to leave the impression that we are not displeased to have received the complaint but are interested at all times in learning from our patrons the condition of our water. Our experience so far has been that the public has responded to this attitude and is more friendly towards the company. Chronic kickers who have been accustomed to call up the office every week or so to make some new criticism concerning the water seem to have lost interest in their self-appointed tasks since they have been encouraged to continue in their good work. Those who have truly been frightened concerning the condition of the water have, upon learning the true situation, gained more confidence in the purity of the water.

While the plan has been in use less than a year, during which time we have had much dry hot weather, conditions under which we normally receive the greatest amount of complaints, we have found that the results from the plan fully warrant the continuation of its practice.

THE SANITARY DRINKING FOUNTAIN[1]

By J. H. Dunlap

The abolishment of the common drinking cup has been a noteworthy achievement. Prohibited in the state of Kansas in 1904, the public cup is today a national outlaw. In October, 1911, the state board of health of Iowa adopted the following resolution:

> Whereas: It has been demonstrated that common drinking cups are frequently contaminated with disease-producing germs and, as a medium for the transmission of contagious and infectious diseases, they are a source of danger to the public health, and
>
> Whereas: Individual or private drinking cups may readily be provided in such places where most needed, therefore,
>
> Under the authority of the statute imposed upon the State Board of Health to promulgate rules and regulations relative to the preservation of the public health in contagious and infectious diseases, and the prevention of the same, the use of the common drinking cup in all public places such as parks, streets, schoolhouses, hotels, factories, workshops, libraries, railway stations and cars and all other public places, is hereby prohibited from and after January 1, 1912.

After the common cup had been removed, it was soon discovered that the expense and inconvenience of providing individuals with private drinking cups was considerable. Accordingly the modern sanitary drinking fountain has been developed and installed in large numbers.

Of course such fountains should be sanitary in fact as well as in name, and yet it is true that the most of them are little better than the old public cup. Recently the writer's attention was called to the dangers lurking in the apparent safety of the modern intermittent bubbling fountain by watching a patient at one of the largest hospitals of the state obtain his drink. The patient opened the valve with his hand just enough so that the bubble was of such a height that he could surround the metal top of the bubbler with his lips

[1] Read October 10, 1916, before a joint meeting of the Illinois and Iowa Sections at Davenport, Iowa.

and almost devour it while getting his drink. A year or more ago a federal inspector in the United States Public Health Service observed the use of a certain fountain. Upon one occasion forty-seven persons drank, and in almost every case the lips were placed upon the metal top of the bubbler. Of the forty-seven who used the fountain three appeared to be tubercular, and three had an eruption upon the face. Anyone who will take the trouble to make the rounds of the present bubbling fountains in his own city will have similar experiences.

To corroborate his own opinion the writer sent out a few random inquiries to state boards of health. The following quotation from one reply is typical:

"It is our conviction from a superficial examination of several types of drinking fountains on the market that they are little better than the common drinking cup."

The so-called sanitary fountain is reprehensible for two reasons; first, it is constructed with too much confidence in the intelligence of the public; and second, it is made with too little attention to the laws of hydraulics. In the first place, then, it must be candidly admitted that even in this enlightened day the average man knows little about the modern science of bacteriology. In fact he knows usually only enough of bacteriolgy to joke at "germs" and "bugs." Illustrations of the prevailing ignorance are all too numerous. For instance, the high average case rate of typhoid in this country, the terrible ravages of tuberculosis, and the almost insane tactics adopted by one's neighbors in cases of small pox or infantile paralysis are only a few of the facts that force the conclusion that the elementary laws of public health are either unknown, or scorned and ignored by the masses. May not the remark be justified, in passing, that it is well nigh criminal that the public schools of the nation are allowed to be so detached from every-day life that its first principles are untaught?

Now it is due to this ignorance and criminal carelessness that the average individual in drinking from public fountains will not hesitate to adjust the height of the jet of water so that his lips may conveniently rest upon the metal of the bubbler. Furthermore if the bubbler is of the continuous flow type the ignorance and parsimonious thrift of the caretaker is apt to cause such a decrease in the height of the bubble as to make it impossible to drink without touching the metal top. In the face of such universal ignorance

and carelessness no bubbler should be called sanitary, or allowed in a public place, which is so made that the lips may come in contact with it.

In the second place not only are these modern fountains constructed without regard to the defects of present-day human nature, but they are seemingly built without sufficient study of the laws of hydraulics involved. The superintendent of buildings for a large institution recently declared that he had been unable to find a bubbler which would work satisfactorily under the ordinary range of working pressures in the service pipes of buildings under his charge. It is often true that while a rush of people are using these fountains, the pressure in the service pipes decreases to such extent that in order to drink one must touch the metal part of the bubbler. Furthermore, in the case of intermittent fountains, the valves are so constructed that all who wish may open them to any size of jet desired. Accordingly if one prefers to drink with the lips touching the metal part of the fountain, it is entirely possible for him to do so. The valves should be so made and the regulating devices so designed that the jet will rise to such a height as to make contact with the metal impossible. Due to the practical impossibility of accomplishing this under all conditions an absolute essential of all drinking fountains is a guard so made that the lips cannot reach the metal top. One would suppose that these facts were sufficiently self-evident, and yet it is very surprising to find in a canvass of the catalogs of thirty-nine manufacturers that only six appreciate these elementary facts, that only six of these thirty-nine equip all their fountains with suitable guards.

Moreover, there is another law of hydraulics which recent researches show that all fountains now on the market violate. This is the law which one observes in action when one sees a ball dancing in the jet of a public fountain. The ball is held there by forces from which it cannot escape, and it will dance for an indefinite length of time in the jet. Now the jets from sanitary fountains are vertical. The question may be asked, what is to prevent bacteria, washed from the lips when drinking, from dancing in the jet until the next individual drinks? The latest experiments have shown that not only is this a possibility, but that it actually occurs. Furthermore it has been shown by actual experiment that the inside of the bubbler becomes at times heavily polluted by the bacteria from the mouth. This may easily happen in the intermittent type of

fountain, for when the water is turned off, the bulb which forms the jet drains out, and accordingly the bacteria may follow the water as it subsides into the interior.

The experiments by which the sanitary fountain with the vertical jet has been discredited were made in the laboratory of medical bacteriology at the University of Wisconsin, and were published only last month.[2] The immediate cause for making these experiments was an epidemic of streptococcus tonsilitis, which occurred in the fall of 1914, in one of the women's dormitories at the University of Wisconsin. After 50 cases had occurred within a week's time an investigation was undertaken. It was found that the water pressure in this dormitory was so low that it was scarcely possible to drink from the bubbling fountains without touching the metal with the lips. A bacteriological examination of these fountains was made and they were found to be heavily contaminated. Streptococci were obtained not only from the surface of the fountain, but also from the inside of it, and from the water issuing from it. The city water supplying the fountains was proved to be free from these organisms. These surprising discoveries led to the investigation of all the other bubble fountains in the University. Forty-three out of 77 of them were found contaminated. A year later similar tests were made of 50 of these fountains and streptococci were found in 70 per cent. of them. As a result of these investigations the following eight conclusions were reached:[2]

1. During an epidemic of streptococcus tonsilitis in a woman's dormitory at the University of Wisconsin, streptococci were found in the bubble fountains in this building and in the water issuing from these fountains.

2. The city water supply was at the time, and has been, excellent in its sanitary character. It is obtained from the underlying Potsdam sandstone. No streptococci were found on a Berkefield filter through which water had been flowing continuously for one week.

3. Presumably the bubble fountains were a factor in transmitting the disease.

4. A survey of all the fountains of the University showed the presence of streptococci in over 50 per cent of the total number. The streptococci varied in abundance from a few chains to an almost pure culture obtained by swabbings from the fountains in the women's dormitory.

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[2] "The bacteriology of the bubble fountain," by Dorothy F. Pettibone, Franklin B. Bogart and Paul F. Clark, published in *Journal of Bacteriology*, September, 1916, vol. 1, no. 5, p. 471.

5. In an experimental bubble fountain, B. prodigiosus, when introduced either by means of a pipette or by the moistened lips, remained in the water from 2 to 135 minutes, depending partly on the height of the bubble.

6. Most of the organisms are flushed away but some remain dancing in the column much as a ball dances on the garden fountain, even though the bubble be increased to the impractical height of 4 inches.

7. To avoid the difficulty always present in the vertical column, a simple fountain with a tube at an angle of 50° from the vertical was constructed. B. prodigiosus was never found in the plates from this type of fountain even when samples were taken immediately after the introduction of the organisms.

8. We believe that this type of fountain should be generally adopted. Its simplicity, low cost of construction and freedom from lurking danger should recommend it to all.

In view of all the facts that have been presented it is believed that three recommendations should be made, as follows:

1. Public sentiment should be aroused to the dangers inherent in the modern drinking fountain. Laws should be passed and enforced requiring the approval of such fountains by state boards of health.

2. Public sentiment and the law should enforce the observance of the principles discussed, not only in the case of public drinking fountains, but also at soda fountains, etc. Is not this question reasonable, why should we be so particular in drinking water but not in drinking other beverages?

3. Since water works men have a good deal to do with the selection of public drinking fountains, it would seem wise that committees should be appointed by the local sections of the American Water Works Association to investigate the present situation and report.[3]

[3] The following committee was appointed by the Iowa Section, J. H. Dunlap, Chairman, Dr. Henry Albert, J. J. Hinman, Jr.

TREATMENT OF MISSOURI RIVER WATER AT COUNCIL BLUFFS, IOWA[1]

By J. B. Thornell

The method of purification in practice at the Council Bluffs city water works is that of coagulation and sedimentation followed by treatment with chlorine for the destruction of bacteria. This process has been used quite extensively for a number of years, so that its operation and effect are familiar to all who take an active interest in water purification. But, although the same general plan of procedure may be in use in many places, there are so many things which may influence its conduct that each plant has its own difficulties and interesting peculiarities.

The water is lifted from the Missouri River into the first group of three settling basins (fig. 1), which have a combined capacity of 8,400,000 gallons. Between basin 1 and basin 2 is a weir 45 feet long, over which the water flows in a sheet about 3 inches deep. The lime and alum used as coagulants are added at this weir. The water passes over a submerged wall between basins 2 and 3. It leaves basin 3 through a jointed pipe, the mouth of which is held within 18 inches of the surface by a float. From basin 3 it proceeds by gravity to the Broadway plant, about one-half mile south of the river plant.

At the Broadway plant is another group of three settling basins; which have a combined capacity of 13,500,000 gallons. As it leaves the last of these basins it receives a charge of chlorine before being pumped into the distributing main.

The clarification of the water is the most difficult as well as the most important part of the process. The greatest trouble is encountered early in the spring. The water thrown into the river by the melting or snow and rains in March and April carries with it a great deal of vegetable stain and light suspended matter which is exceedingly hard to remove. The chemical nature of the raw water at

[1] Paper read before a joint meeting of the Iowa and Illinois Sections at Davenport, Iowa, on October 10, 1916.

this time undergoes rapid and wide changes. The organic content is greatly increased. The alkalinity takes a sudden drop and the suspended matter, although its amount is not so great as is usually

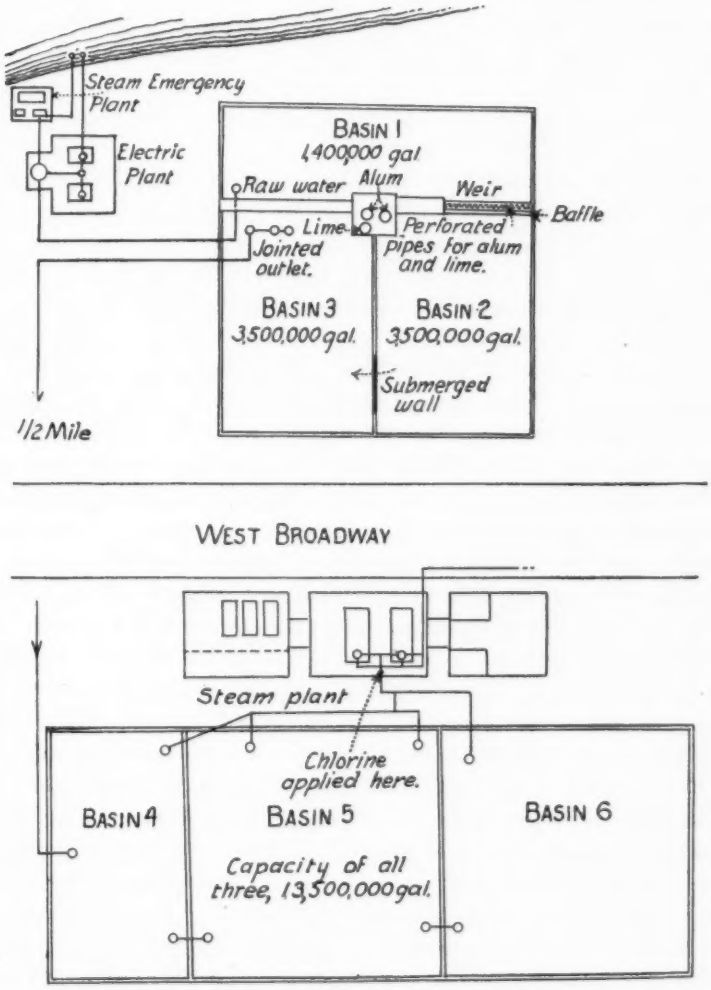


FIG. 1. SCHEME OF PURIFICATION PLANT

found later in the spring and summer, carries an enormous number of bacteria.

The most unusual change of this nature which we ever observed came in February and March, 1915. A period of warm weather

and rain melted the snow, which was unusually heavy that winter, and thoroughly flushed the surface of the ground for the first time in three or four months. The change was so sudden that an immense volume of soft water laden with silt, bacteria and organic matter rushed into the river. The organic content of the raw water increased 300 per cent and the alkalinity decreased 50 per cent. The coagulating action of the alum was almost completely destroyed, for it was combining with the organic matter in the water instead of forming the flocculent hydroxide. Our tap water became very turbid and it was necessary to add an excess of calcium hypochlorite solution as a safe guard against harmful bacteria. We were using alum alone for coagulation at that time but this experience convinced us that it was inadequate under such conditions. Hasty preparations were made for the use of hydrated lime as an adjunct to the alum. The lime solution was injected at the intake line of the low-service pumps which lift the water from the river into the settling basins. This arrangement was a great aid in the removal of suspended matter during the remainder of the trying period of high water, but the apparatus was crude and there were great disadvantages in applying the solution in the suction line of the pumps. This part of the treatment was, therefore, discontinued after a few months and experiments were begun toward perfecting better apparatus and finding the most advantageous point of application.

We are now adding the lime to the water at the weir between basin 1 and basin 2 through a perforated pipe extending over the entire length of the weir. The device for feeding the lime is located in the gate house near the weir. A large iron hopper is filled with dry lime. In the bottom of the hopper is a worm which pushes it into a smaller, funnel-shaped hopper below. A stream of water flows into the lower funnel dissolving the lime and carrying it out through a 2-inch pipe to the weir. A small electric motor drives the feeding device and is also attached to a small centrifugal pump which draws from one of the settling basins the water for dissolving the lime. By an arrangement of pulleys and gears the speed of the worm may be regulated as desired. About 30 gallons of water are used for each pound of lime. The large volume of water used is one of the main factors in the success of the treatment, because it completely dissolves the lime, thereby preventing clogging of pipes and bringing about thorough mixing of the lime solution with the raw water before it receives the charge of alum solution.

The alum solution is applied through a second perforated pipe immediately after the lime solution. The amount of alum required varies between 1 and 3 grains per gallon and the amount of lime varies between $\frac{1}{2}$ and $1\frac{1}{2}$ grains per gallon of water treated.

Comparison of the available data on the turbidity of the settled water and of the water at the point of application of the coagulants, and calculations of the costs of coagulants before and since the use of lime as an aid to alum was commenced, show that a much better quality of water has been obtained by the use of lime with the alum and that it is more economical than the use of alum alone.

A glance at the accompanying table gives a fair idea of the results obtained by the use of lime with the alum from April 1 to September 1, 1916, as compared with those obtained by using alum alone during the same months of 1914. In 1916 the raw water contained 17 per cent more suspended matter than in 1914. The turbidity of the settled water was reduced 81 per cent and the comparative cost of coagulants was 11 per cent less in 1916 than in 1914.

Comparison of turbidities and cost of coagulants, April 1 to August 31, 1914 and 1916

MONTH	TURBIDITY OF WATER AT POINT OF APPLICATION OF COAGULANTS. PARTS PER MILLION				AMOUNTS OF COAGULANTS USED. GRAINS PER GALLON				TURBIDITY OF SETTLED WATER. PARTS PER MILLION				COST OF COAGULANTS PER MILLION GALLONS.* (BASED ON 1914 PRICE OF ALUM)			
					1914		1916									
	1914	1916	Increase	Decrease	Alum	Lime	Alum	Lime	1914	1916	Increase	Decrease	1914	1916	Increase	Decrease
			per cent	*per cent*							*per cent*	*per cent*			*per cent*	*per cent*
April.....	1212	2222	83		2.3	0	2.4	1.1	6	2		66	$3.19	$3.88	21	
May.....	1299	1078		20	2.9	0	1.2	1.2	5	1		80	4.03	2.27		43
June.....	1695	1196		29	3.1	0	1.8	1.1	11	2		81	4.30	3.05		29
July.....	1506	1873	24		2.5	0	2.2	1.3	24	2		91	3.47	3.70	6	
August.....	758	1248	64		2.0	0	1.8	1.1	8	2		75	3.05	3.05		
Average....	1294	1523	17		2.6	0	1.8	1.1	11	2		81	3.61	3.19		11

* Alum (1914), $9.75 per 1000 pounds; lime, 1916, $3.50 per 1000 pounds. (These prices do not include freight.)

Due to three hours' natural sedimentation in basin 1, the water as it passes over the weir has an average turbidity which is only 35 per cent of the average turbidity of the raw water. Experiments in the laboratory and actual experience at Council Bluffs show that

in the clarification of water carrying such great quantities of suspended matter as are found in the Missouri River water a great saving in the cost of coagulants can be brought about by allowing ample time for natural sedimentation before adding the coagulants. This fact is clearly shown in the table.

The upper three curves in figure 2 show the stages of the river in feet above low-water mark, the turbidity of the raw water and the number of bacteria per cubic centimeter of raw water. It is readily seen that the three curves follow one another quite regularly. The only noticeable divergence from the usual course is shown in the very marked increase in the number of bacteria in the raw water in January and February, 1916. Our record of local weather conditions shows that unusually warm weather prevailed for three different periods in those two months, but the changes in temperature, evidently, were not general enough to affect the turbidity of the river, although they were sufficient to cause a moderate rise in the river stage. The highest counts of bacteria in the raw water are found early in the spring, although the turbidity and stage of the river do not reach their highest points until June or July. From this it would seem to be a reasonable conclusion that the most of the bacteria found in the water at that time are soil bacteria which are generally classed as non-pathogenic.

Figure 2 also gives curves for the alkalinity and total hardness of the tap water in parts per million. The alkalinity and hardness follow each other quite closely but both vary inversely as the river stages. Judging from these curves it would seem that the amount of dissolved mineral matter which is carried past a given point on the bank of the river does not vary greatly from month to month but that the variation in alkalinity and total hardness are caused principally by greater or less dilution.

As shown in figure 3 the number of bacteria in the settled water before chlorine treatment and the turbidity of the raw water are inversely proportional to each other. This point emphasizes the great importance of the process of clarification. The coagulation and sedimentation of the suspended matter remove mechanically from 85 to 99 per cent of the bacteria.

After passing through the settling basins the water is treated with chlorine for the removal of bacteria. The use of liquid chlorine was commenced in March, 1915. The amounts of chlorine required have varied between 0.2 and 0.3 part per million and the average amount

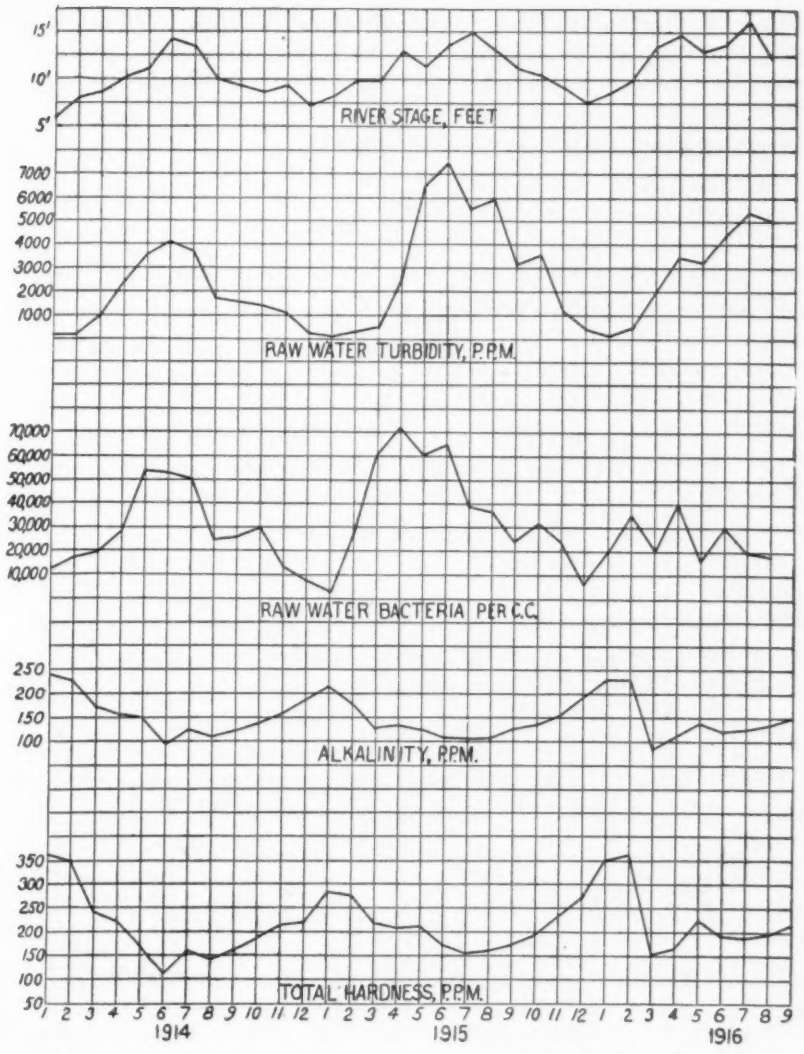


FIG. 2. RIVER STAGES, TURBIDITY AND BACTERIA IN RAW WATER, AND ALKALINITY AND TOTAL HARDNESS OF TAP WATER

was 0.247 part per million or 33 ounces per million gallons of water treated. Including freight on the cylinders the chlorine has cost about 11 cents per pound or 22½ cents per million gallons of water. Previous to the installation of the liquid chlorine apparatus, calcium hypochlorite in the amount of about 8 pounds per million

gallons of water was used for sterilization. That was before the war price was put on bleach. Including freight it cost a little less than $2\frac{1}{2}$ cents per pound or about 20 cents per million gallons of water treated. This means that the use of liquid chlorine has made no marked change in the cost of sterilizing reagent in normal times.

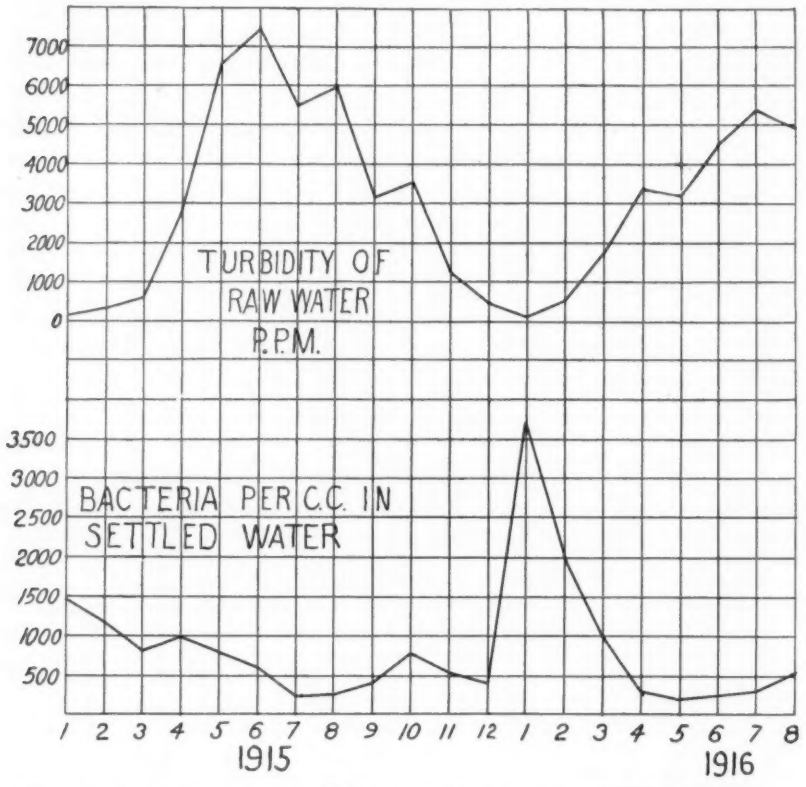


FIG. 3. TURBIDITY OF RAW WATER AND BACTERIA IN SETTLED WATER

The greatest advantages derived from the use of liquid chlorine in sterilization are in the ease of operation and the steadiness of the treatment. We have found that our chlorine apparatus can always be depended upon, whereas we were almost constantly troubled with clogging of pipes and a great inconvenience in handling the hypochlorite.

The average counts of bacteria in the tap water have not shown any marked change since the use of liquid chlorine was commenced.

For the first eight months of 1916, the average number of bacteria in the tap water was 48 per cubic centimeter. During the same eight months of 1914 when hypochlorite was in use the average was only 31. This difference is partly explained by the fact that in the summer of 1916 copper sulphate was used from time to time for the destruction of algae in the settling basins and that treatment was always followed by high counts of bacteria in the settled and tap water. The bacteria which increased so rapidly after the copper sulphate treatment seemed to be quite resistant to chlorine but they are harmless soil bacteria and of little or no importance to the sanitary quality of the water.

The presumptive tests for B. coli in the tap water in the past eight months have given positive results in only 3 per cent of the samples tested. There are still improvements to be made and economic measures to be investigated in connection with the treatment. Our system and the quality of the supply lack much of being perfect. The softening of the water during the winter months; more effective baffling of the water; a longer period of natural sedimentation before the addition of the coagulants; a more satisfactory treatment for the destruction of algae; and the home manufacture of alum are some of the things which must be investigated and each must be taken in its turn. Up to this time our attention has been occupied by matters which pertained principally to making the supply *safe* and *wholesome* and as nearly constant in quality as possible. Our efforts must now be turned more particularly to matters of economic efficiency.

SOME PROBLEMS OF THE WATER WORKS EXECUTIVE[1]

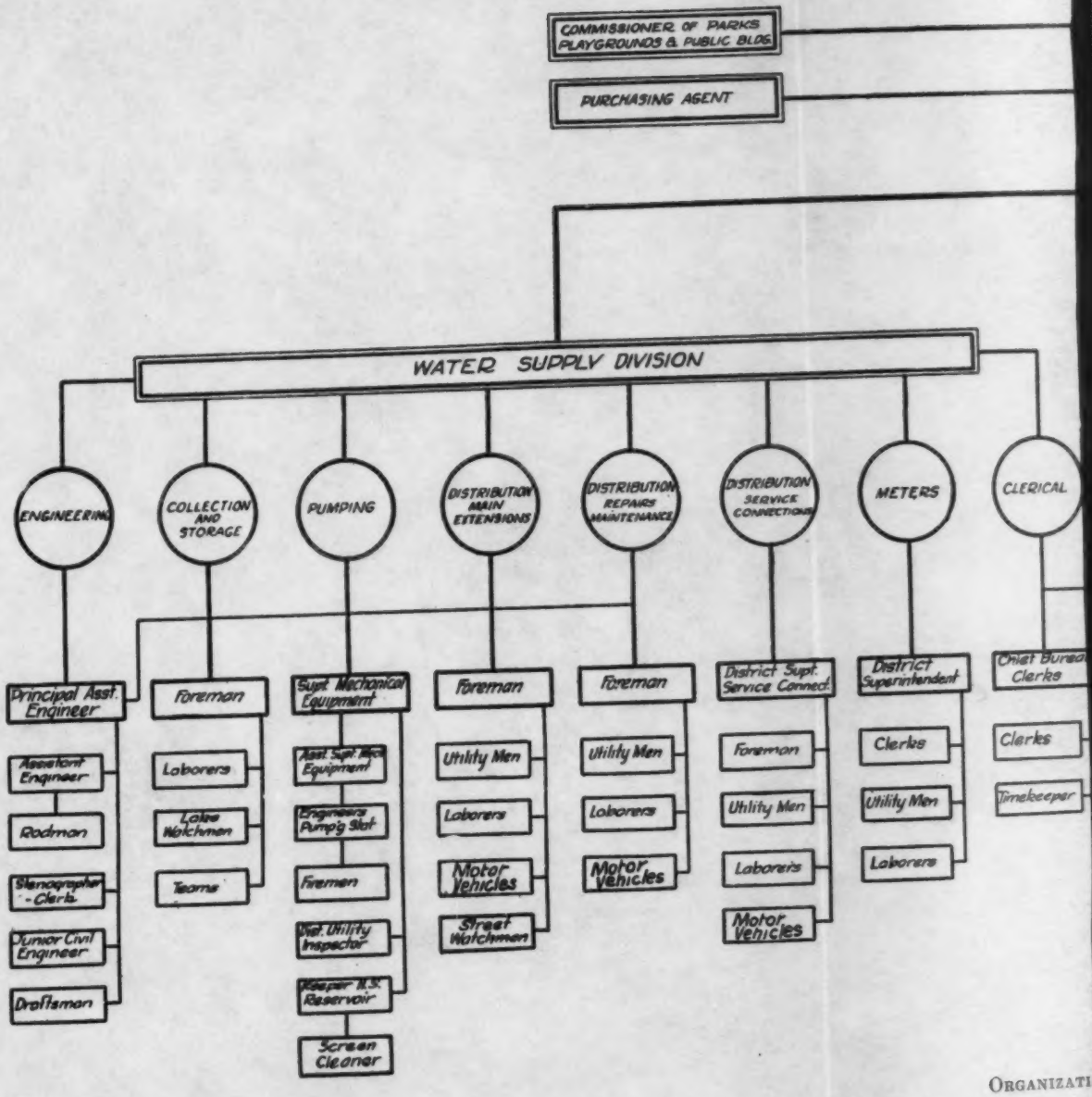
By Garrett O. House

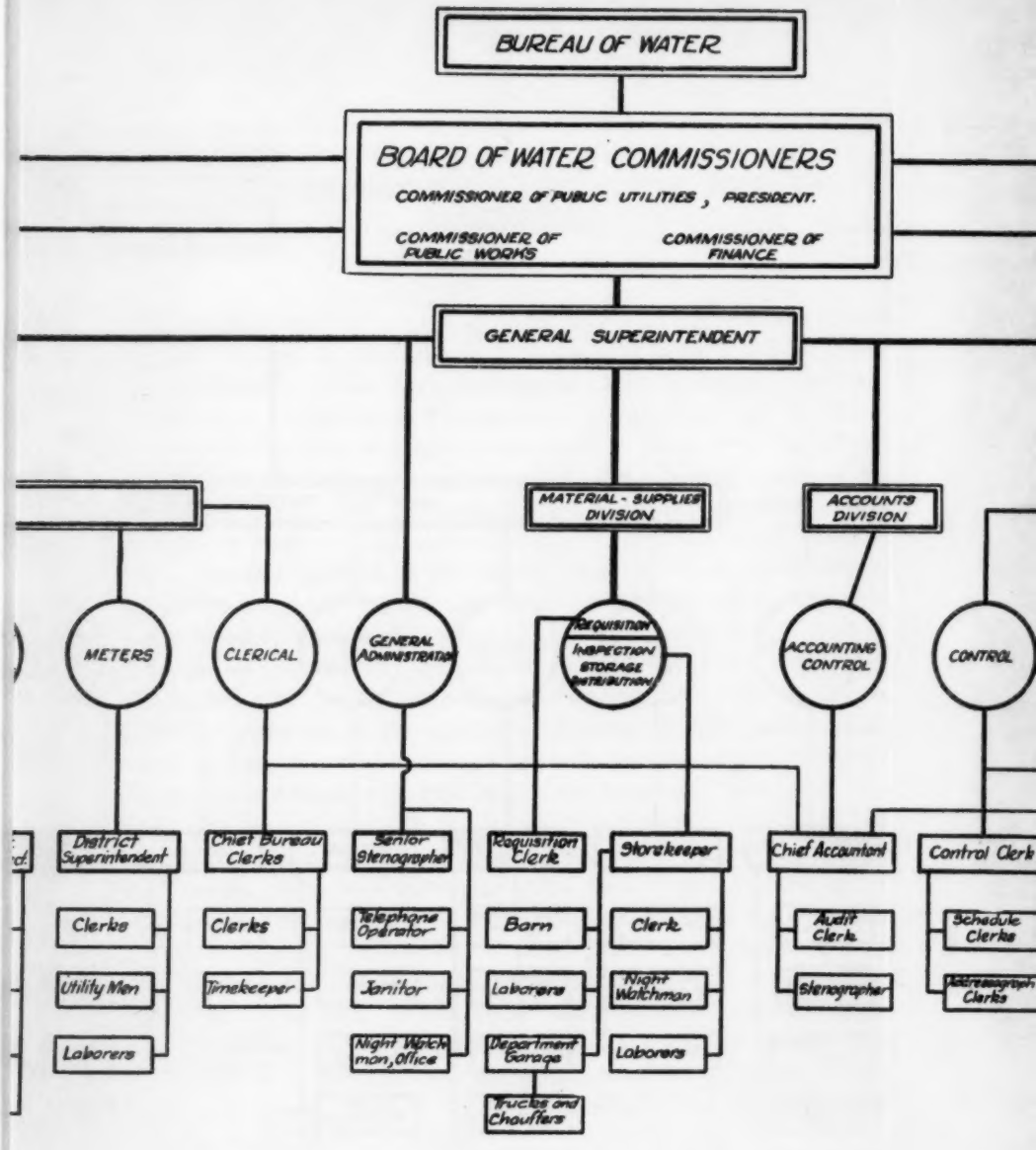
In considering this subject, it seems to me fitting that we should analyze briefly, if you please, the qualifications which a water works executive must have, because in order to properly operate and manage a water works he must have some specific qualifications.

The water works executive is expected to administer the affairs of his office efficiently, and inasmuch as the efficiency equation involves the proper way to do work, and also the way work is performed, he must be qualified to know how the different divisions of his department should be conducted, how individual work should be performed, and he must also know how the actual work is conducted and how much is accomplished. Some one has said that an executive is called upon to make rapid decisions and is sometimes right, that most of his answers must be "yes" or "no." This is probably borne out in the experience of every executive and emphasizes the importance of knowing how each branch of his department should be operated, and also how it is operated. He must also know the means available in men and equipment. It is possible for him to determine how work is done by records properly arranged, and results. The way work should be done he must know either through his own experience or the experience of others of recognized ability. He must be idealistic. How little worth while is ever accomplished without an ideal. It is the real incentive for accomplishment. The ideal of the water works executive is furnishing an adequate amount of pure and wholesome water for all purposes to all citizens indiscriminately, under reasonable conditions and at reasonable rates. This is the main problem, and its fulfillment involves many lesser problems.

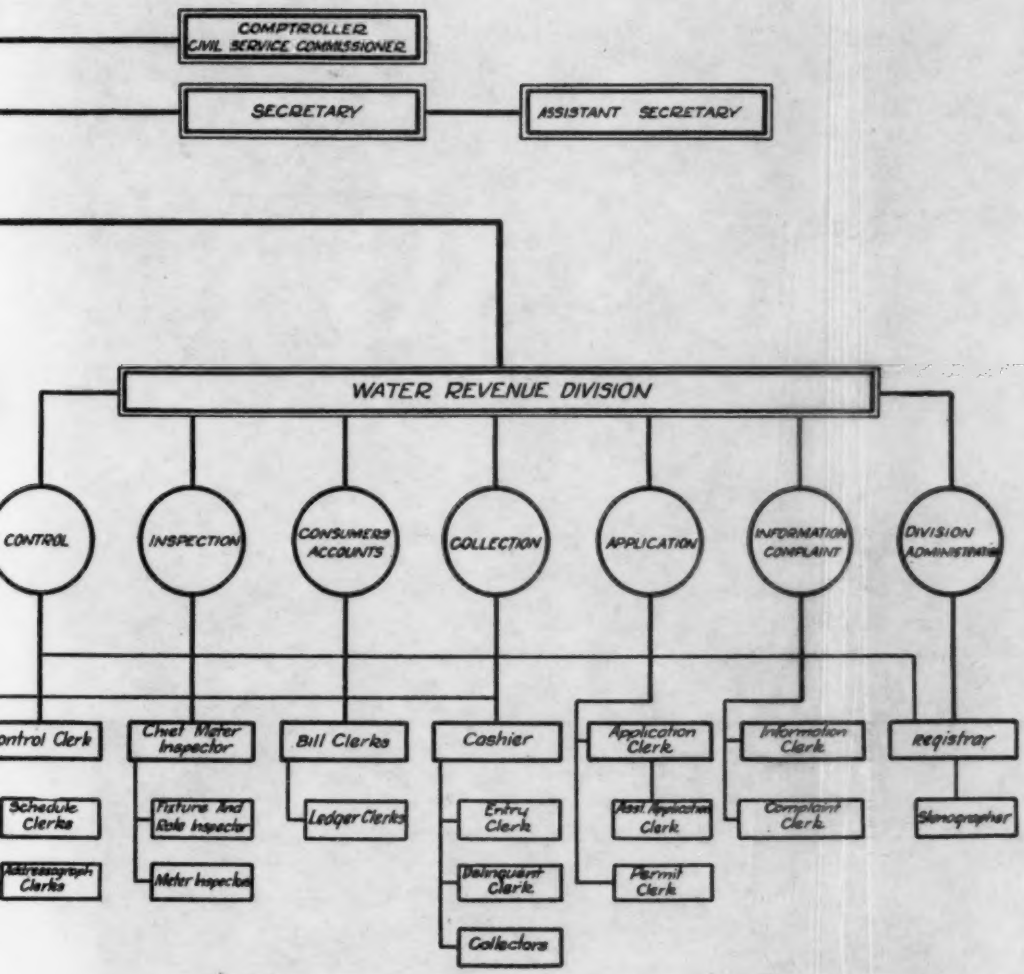
In speaking of an ideal water works organization it has been said that the manager or executive must have, in addition to foreknowl-

[1]Read before a meeting of the Minnesota Section at Minneapolis on December 2, 1916.


COMMISSIONER OF PARKS PLAYGROUNDS & PUBLIC BLDS.
PURCHASING AGENT
WATER SUPPLY DIVISION
ENGINEERING
COLLECTION AND STORAGE
PUMPING
DISTRIBUTION MAIN EXTENSIONS
DISTRIBUTION REPAIRS MAINTENANCE
DISTRIBUTION SERVICE CONNECTIONS
METERS
CLERICAL
Principal Asst. Engineer
Assistant Engineer
Rodman
Stenographer - Clerk
Junior Civil Engineer
Draftsman
Foreman
Laborers
Lake Watchman
Teams
Supt. Mechanical Equipment
Asst. Supt. Mech. Equipment
Engineers Pump'g Stat.
Firemen
Dist. Utility Inspector
Keeper W.S. Reservoir
Screen Cleaner
Foreman
Utility Men
Laborers
Motor Vehicles
Street Watchmen
Foreman
Utility Men
Laborers
Motor Vehicles
District Supt. Service Connect.
Foreman
Utility Men
Laborers
Motor Vehicles
District Superintendent
Clerks
Utility Men
Laborers
Chief Bureau Clerks
Clerks
Timekeeper



Organization Chart of the Bureau of Water of St. Paul, Minn.


COMPTROLLER
CIVIL SERVICE COMMISSIONER
SECRETARY
ASSISTANT SECRETARY
WATER REVENUE DIVISION
CONTROL
INSPECTION
CONSUMERS ACCOUNTS
COLLECTION
APPLICATION
INFORMATION COMPLAINT
DIVISION ADMINISTRATION
ontrol Clerk
Chief Meter Inspector
Bill Clerks
Cashier
Application Clerk
Information Clerk
registrar
Schedule Clerks
Addressograph Clerks
Fixture And Rate Inspector
Meter Inspector
Ledger Clerks
Entry Clerk
Delinquent Clerk
Collectors
Asst Application Clerk
Permit Clerk
Complaint Clerk
Stenographer

edge of water works work, that is, experience, resourcefulness in high degree, initiative, and ability. I think we will all agree to that, but is not his success as an executive measured also, and to a very large extent, by his personality? I am not thinking of a water works executive as one who plans his work separate and apart from his associates and who executes by written order, but of a man who knows full well what is to be done and directs its accomplishment by coöperation with those associated with him; who works through the organization which is set up, to accomplish his ideal; who thinks of the organization as "a systematic coöperation of a body of men for a common purpose," the common purpose being to reach his ideal. His personality is reflected in every branch of his organization. He is the leader, or executive. His integrity, his enthusiasm, his tact, his character, has its influence upon each individual in the organization. As John Stewart Mill has said, "the initiative of wise and noble things comes, and must come, from individuals, and generally first from one individual." Personality is individual. It is the contribution of ourselves, not of muscle, or money, or brains; it is that which makes an organization better for our having organized, deputized and supervised it.

In order to bring out the problems of the water works executive, I will, because of my intimate knowledge and connection with the bureau of water in St. Paul, analyze the organization chart of the water department of the city of St. Paul. As will be noted on the accompanying graphic representation of our organization, the commission form of charter under which the municipality of St. Paul is governed, provides that the affairs of the water department shall be administered through an elective board of water commissioners, of whom the commissioner of public utilities is president, and the commissioners of public works and of finance are members. The charter provides that the commissioner of public utilities shall administer, as president of the board of water commissioners, all of the general business of the water department; that the commissioner of public works shall have charge of all engineering and construction; and the commissioner of finance shall collect all revenues. The charter also provides for a central purchasing agent who purchases all supplies and material used by the water department; also that the comptroller shall prescribe the method of accounting and audit all accounts of the water department. He also, as civil service commissioner, certifies to the eligibility of all employes and also

audits all payrolls. From this it is evident that the activities of the water department are, by charter provision, placed in the hands of many individuals. Since all of these activities are dependent and interlock one with the other, it was deemed necessary and advisable for each of the elective officials to deputize one person to administer, under their direction, the authority which the charter has vested in them. To this person has been given the title of general superintendent and he becomes the executive of the water department.

The first important branch of duty which falls to the lot of the general superintendent can be properly considered under the head of general administration, in which is involved the problem of making rules and regulations for the conduct of all water works business.

Rules and regulations are really the articles of agreement between the consumer and the water works, under which the water works company or department agrees to render service and the consumer agrees to comply therewith. Usually all forms of contract procedure which the applicant for water service signs include or state in a different way some of the rules and regulations of the department. To prepare rules which will be reasonable, be general in application and not discriminate in favor of any person, is a real problem. And yet the problem is rendered more easily solved when the executive keeps constantly in his mind that all rules must be based upon reasonableness, and if, in addition to considering the needs and requirements of the water department, he also considers the needs of the water consumers. In other words, he must place himself in the consumers' position and form rules and regulations in accordance with the Golden Rule. Rules and regulations are of great importance to the welfare of the water department, but none should be made unless it can be enforced or lived up to; all should be reasonable, fair to the water works and fair to the consumer.

A water works as a rule is a monopoly and the opportunity is given to make unreasonable rules, decidedly in favor of the company or department. Water is a necessity and no commodity contributes so much to the health and prosperity of a community as water, therefore the service should be within the reach of all.

Under this same general heading may be considered rates, which, however, are determined not upon theory but from actual facts. The water works executive, having made the rules and regulations and rates under which the department is to be operated, now turns his attention to perfecting an organization through which all the

various activities of the department may be carried on, and the rules and regulations laid down may be carried out.

You will note that the organization of the water department of the city of St. Paul is divided into four separate divisions, water supply division, water revenue division, accounts division, and materials and supplies division. Time will not permit the consideration of problems of the water works executive which involve engineering. Let us consider, therefore, first, what problems, if any, are to be found under the heading "Distribution, main extensions." How should extensions be made in the newly developed portions of the city? In St. Paul, one general rule is followed. If the street upon which the extension is asked, is graded to the grade established by the city engineer, and if there is a reasonable demand for water on this street, a petition for main extension is usually granted by the board. This liberal policy can be pursued in St. Paul because of the fact that a frontage tax is permitted under its charter amounting to $1 per front foot of all property facing on the street upon which the main is laid, which reimburses the department for the expense of installing the main.

An engineering problem of great importance is also involved in the matter of extension of mains, particularly in a rapidly growing city, concerning which time will not permit a discussion in this paper. The location of the water main in the public street at any other point than at the center involves a greater expense to owners on one side of the street than the other in making a service connection.

The problem of taking care of repairs and maintenance of water mains and appurtenances must, I think, be worked out in each individual case, because conditions vary in almost every city. One thing, however, is certain, that the selection of men to perform this class of work must be in every sense emergency men.

Under the next sub-division, "Distribution, service connections," many problems are involved, including the materials of which service connections are to be made, the method of installing them, whether by the water department or a licensed plumber in the service of the owner of the property to be served, the size permitted, and the location of the control fittings. In St. Paul extra strong lead pipe is used for all service connections up to and including 1½-inch; for 2-inch, galvanized iron pipe is used, and for larger service connections, cast iron. All services are laid by the water department. Not only is there a question of who should lay the water

service connection in the street, but there is also the question of who should maintain it. In St. Paul, at present, it is laid by the water department at the expense of the owner of the property and thereafter maintained by the water department, also at the expense of the owner of the property. From experience I would say that this arrangement is not the best, and I am preparing a new schedule of rates for laying service connections which will include the cost of their maintenance throughout a period representing their reasonable life, which I will ask the board of water commissioners to put into effect on January 1.

In this division we also have the problem which, as yet, remains unsolved, service connections to private fire supplies. This has been a subject of much discussion in engineering and water works societies, and there is a decided difference of opinion. It is a most important problem and I believe should be solved by accepting a procedure midway between the theory of the National Board of Fire Underwriters and the practice of some water works engineers and executives.

It seems to me that the provisions of the National Board of Fire Underwriters with respect to the size of service connection necessary for supplying automatic sprinkler equipment is in many cases entirely too liberal and does not take into consideration the elements which must enter into a determination of water supply. The board of fire underwriters requires, for instance, that a 6-inch service connection must be supplied for sprinkler equipment located in one fire area in excess of 85 sprinkler heads. No consideration is given the matter of pressure, and notwithstanding the fact the National Board indicates that one sprinkler head will reasonably protect 10 square feet of area, the manufacturers of automatic sprinkler equipment very often plan and install sprinkler equipment so that one head is placed to considerably less than 10 square feet of area, which makes, under the rules of the National Board of Fire Underwriters, the larger size service connection necessary.

The use of water from the fire service for other purposes than extinguishing fire, is a problem which confronts the water works executive, and is generally dealt with either by sealing and inspecting all drip valves on the system, or by placing some form of meter or detector in the service line. In my judgment, a clear distinction should be made between supplies to be used for extinguishing fires and those to be used for domestic purposes, and under no considera-

tion should domestic service be taken from a fire supply line. The charge made for private fire service should include water consumed for periodical testing of the system, losses from evaporation and water used for extinguishing fires. This being the case, it is only necessary to introduce in the service connection a device which will indicate that water has been used. The question of how much is not important. This will effectually prevent continuous use of water for any purpose other than that for which the service is installed. If it is found, for instance, that the service is used more frequently than would be necessary for inspection or make-up water, inquiry can be promptly made and the proper remedy applied. It is, I think, important that the consumer to whom private fire service is supplied, should be required to give a bond of sufficient size to guarantee fulfillment of contract provisions. There is also the necessity for the adoption of uniform practice in this respect by all water works operated under the same general conditions.

The next problem which confronts the water works executive is that of meters, and there is little question but the selection of water meters is a problem to every water works executive. This problem is more complicated in a municipality where the charter and ordinance provisions are in force similar to those in St. Paul, where the central purchasing agent is required to award a contract for purchases exceeding in amount $500, upon formal bids, to the lowest responsible bidder. This makes it necessary for the executive to prepare specifications which will either represent the water meter his judgment considers the best, which would be considered discriminatory, or else prepare an open specification which shall permit the manufacturers of all water meters to bid and be satisfied to accept that meter which will be furnished for the lowest price. Two years ago, when this provision was first in effect in St. Paul, bids were received for water meters upon a general specification, and after tabulation, the contract committee asked the writer to make a recommendation. Knowing full well the provisions of the charter with respect to purchases of all supplies, the following recommendation was made:

> It is my judgment that the city should buy that meter which, in addition to complying in all respects with the specifications, represents the lowest unit cost during its life, the determination of which involves an equation having only one known quantity (first cost) and several unknown quantities.

Meter representatives and others maintain that the records of the department should indicate the cost of maintenance of the meter. This is true, but notwithstanding the fact that the same size and make of meter purchased at the same time and performing the same service for several years, will require distinctly different repairs and maintenance, and be distinctly different in the matter of test at the end of this period, the average represents the best information obtainable and would be quite satisfactory. The problem is how to introduce such a provision in the specifications.

For both service connections and meters, history cards are started when the service connection is installed or the meter is purchased. Upon these cards are recorded all that happens to the service connection or the meter, including all elements of expense. These cards are found of great value because they represent the life history of either the service connection or the meter.

The problems involved in the material and supplies division are very interesting. Time will not permit their analysis in this paper.

The accounts division is of great importance but is not always given the attention it should have.

The water revenue division, as you well know, represents the activities of the department of the water works which come in direct contact with the public. On this account many problems are involved, particularly in its organization and administration. You will note that the organization of the St. Paul water works is administered by a registrar who directs all of the sub-divisions. These sub-divisions are made so that each man has a separate and distinct branch of business to transact, affording the person who has business with the department the facility of transacting it rapidly and avoiding what is so common, being referred from one division to another. Information and complaints are given very careful consideration in our organization, and the heads of these sub-divisions are trained and cautioned to always assume that every complaint is real to the complainant and not to take uncomplimentary remarks about the department as personal. It is here that calmness and courtesy count; our slogan is "Service."

In making up the organization chart to which reference has been made, it is intended to classify and group the different functions logically, making a single officer responsible to the general superintendent for the direction of each function. The functions of each sub-division have been clearly defined by bulletin and the duties

and lines of authority of each position have been standardized and defined. While experience has shown that this organization has operated smoothly and accomplished very definite and satisfactory results, it is also shown that slight readjustment in some of the divisions will give better results and these changes will be made at an early date. An executive must train himself to be awake, to make changes in his organization when experience shows that the change is necessary and will effect an improvement in administration.

I would like to add just a word or thought as to the routine business of a water works executive, the problems he is called upon to solve other than through his organization.

It is important, of course, and necessary that he should refer all matters possible to his associates, to the heads of different divisions, rather than attempt to work them out himself; this is to avoid confusion. This, of course, is absolutely necessary, but there are many matters which come to him which require his individual effort. He must be able to differentiate between the big things and the little things, the important things and the unimportant things, holding only for his own personal consideration that which he must of necessity do or where the solution has an important bearing on the general plan of the department.

I have heard a water works executive with whom I am well acquainted express himself to the effect that unfinished business was a most unsatisfactory problem to solve; that he recognizes the fact that to solve a problem properly it is necessary to concentrate upon it; to analyze the fundamentals and work upon it to its conclusion. How seldom is this possible for the ordinary executive to do. He no sooner gets started upon a problem, if he attempts to do it during office hours and in his office, and gets his mind thoroughly fixed upon it, when he is interrupted by the introduction of some other equally important business, which so diverts him that he loses the thread of what he was working on and thereby seriously diminishes his ability to make the best solution. Then again, how often problems are before him which cannot be brought to a conclusion, but must be left in the unfinished state until late developments.

The executive is called upon also to administer or prescribe discipline and exercise authority. Here perhaps, as well as anywhere, is shown his personal characteristics. He must use the hand of steel enclosed in the glove of velvet. He must have a highly developed sense of fairness, be firm and yet reasonable, and above all, practice the Golden Rule.

SWIMMING POOL OPERATION[1]

By Jack J. Hinman, Jr.

Swimming pool operators are naturally desirous of making the use of the swimming pools under their control as pleasant and as safe as possible for those who use them. The swimmer thinks first of the convenience and appearance of the pool and its appurtenances, and of the temperature, clarity, odor and taste of the water. If these are satisfactory he is inclined to assume that the water is safe for use. In the design of pools at the present time more thought is given to convenience and appearance than was given in the past and a great deal more consideration is given to the devices which insure a safe water in the tanks. Fewer pools are now located in dark basement rooms, while more and more pools are constructed with plenty of provision for light, thus insuring greater attractiveness as well as better sanitary conditions.

Design. A swimming pool should be constructed so that it can be kept clean easily. The tank should be watertight, of course, with walls of brick, stone or reinforced concrete, and it should have a smooth lining of enameled tile or similar material. All corners should be rounded to make cleaning easier. There should be no unnecessary obstruction of the sides by hand rails, steam pipes or other fixtures. The combined hand rail, expectoration and overflow trough should be used, and should extend entirely around the tank. It is well to give the bottom of the tank a kind of hopper-shape so that the deepest part of the pool may be where men from the diving board or platform will enter the water. The drain-pipe of the pool should be large. It should never be less than 4 inches in diameter. This will prevent an unnecessary waste of time when the pool is emptied. In some places quick-emptying devices are provided in case of accident.

The pool water should enter through orifices near the surface

[1] Read at the joint meeting of the Iowa and Illinois Sections at Davenport, Iowa, October 10, 1916.

at the shallow end of the pool and be withdrawn through openings at the lowest part of the deep end. There should be sufficient force in the stream of incoming water to cause a distinct current. In this way sediment and floating matters are carried toward the outlet and the polluted water is most effectually removed or diluted. Wherever the water removed from the tank is constantly purified and returned or the process of continuous addition of water is used, this manner of adding the water will be found most effective in removing objectionably polluted water and sediment.

The best method of heating water, especially where filters are used, is by means of coil heaters before the water is passed through the filters. Where waters of high carbonate hardness are used, the addition of steam drives off much of the free and half-bound carbon dioxide with the production of turbidity in the pool. The filters will retain this material although there is a greater tendency toward cementation of the sand bed as a result. The type of filter best adapted to this work is a pressure mechanical filter. It should be provided with a manual agitation device as well as arranged to wash the filter medium by a reverse flow of pool water. The purpose of the manual agitator is to provide a positive means of preventing undue cementing processes. Filters of the pressure type may be insulated by asbestos and so save a considerable portion of the heat which has been given to the water. The operation of filters and the treatment of the water will be discussed in greater detail below.

The path around the pool should be wide enough to permit two people to pass easily. The cement or tile of which it is made should be pitched away from the pool to avoid water running back and increasing the contamination of the pool water.

Convenient toilets with entrances to the pool room should be provided. The easier they are of access the less will be the urinating in the pool and the less the contamination from such source.

The importance of shower baths is generally recognized. However, it is hard to have efficient supervision over the bathing. If suits are worn the shower-bath should be taken before the suits are put on. This requires a sort of private bathing booth for each individual's use. In Y. M. C. A. pools and men's pools where no suits are worn, the shower bath may be taken before the instructor or attendant who can then see that the bath is sufficiently thorough. These showers may be conveniently situated in the pool room itself.

The presence upon the platform of the pool, of visitors wearing street shoes, is objectionable since they carry dirt into the room. This in turn may be carried into the pool upon the feet of the bathers. In order to avoid this, as well as to allow a better view of pool activities, galleries for visitors are very desirable.

The advantages of a well-lighted room were mentioned above. The attractiveness is much increased if the ceiling is very high, two stories in the clear, with the visitor's gallery located at the level of the floor above.

The walls of the pool room should be made of some smooth washable material, such as white tile. Any wall or ceiling finish which is attacked by moisture should be avoided, since the air will be water-saturated most of the time and sweating may produce stains of rust, etc.

Use. It is a well-known fact that upon our bodies there are vast numbers of bacteria most of which are probably harmless. Since the number of these bacteria varies inversely as the care with which we keep our bodies clean, it readily follows that the cleaner the users of the pool the less the pollution of the water if it is used by the same number of swimmers. Bunker and Whipple (1) say that a dirty hospital patient was found to have upon his body 25,000,000,000 bacteria, while a man of clean habits and smooth skin had 3,000,000,000 and a man of clean habits whose skin was hairy harbored 14,000,000,000.

The shower bath taken before entering a swimming pool should be a thorough one as has been mentioned before. It should be taken with warm water and soap, and if possible, should be supervised by an attendant. The soap should be provided, otherwise its use may be omitted altogether. Plenty of soap should be used and care should be taken to see that the hair (unless rubber caps are worn) and the entire body are well washed. As was mentioned before, showers should be taken before the bathing suit is put on as otherwise a thorough cleaning is not likely to be obtained. The path from the showers to the pool should be kept clean to avoid soiling the feet of the bathers. Bunker and Whipple further mention that the feet of a boy about to enter the pool were found to yield 80,000,000 bacteria.

Where suits are worn special precautions should be taken to see that they are kept clean. Only light colored suits should be permitted, since dirt may be more easily noticed on such suits and the

dye of colored suits sometimes stains the water of the pool. The suits should be washed after each use. If properly washed they will be sterile or nearly so. For the protection of the bathers the towels supplied should be as carefully washed as the suits.

In most pools a satisfactory physical examination of all bathers cannot be made and the attendant must inspect the bathers as best he can while they are entering the pool room or bathing under the showers. Any person who is suffering from a skin eruption, infection of any kind, a cough or cold should be excluded if noticed. The practice, common in men's pools, of going without the swimming suit or wearing only small triangular trunks is a help to the attendant in looking for infections, etc. The use of the expectoration trough should be required and swimmers should be told why it is objectionable for them to spit into the pool water.

Infection. It is probable that many cases of infections of various kinds have been laid unjustly at the door of the swimming pool. There are, however, a considerable number of recorded cases believed to have been due to contaminated pools and streams. Atkins (2) has divided the infections obtained by bathers in swimming pools into three classes:

1. Intestinal infections, as typhoid fever, dysentery, etc.
2. Eye and ear inflammations, like conjunctivitis, rhinitis and ethmoiditis.
3. Gonorrheal infections.

To this classification Levine (3) has rightly suggested the addition of

4. Infections of the respiratory system, like grippe, colds, pneumonia, sore throat and sinus infections.

I shall not enter into a discussion of these disorders, or of the recognized possibility of bacterial carriers infecting the water. I merely refer to the works of Baginsky (4), Cobb (5), Balduan and Noble (6), Rosenau, Lumsden and Kastle (7), Mair (8), Burrage (9), Williams (10), Atkins (2), Manheimer (11) and many others.

The bacterial contamination of the water of swimming pools falls into two classes, the remote and the recent. The latter is of greatest importance. The pathogenic organisms are accustomed to the warmth of the body and to a profusion of food material. Thrown into the comparatively cold environment of the pool water, where food is more scarce, they die or rapidly lose their characteristics. For this reason the man who swims past you is a more real danger to you than the man who added his quota of dangerous bacteria to the pool yesterday.

Remedies. A vital question, then, becomes how best to render harmless the bacteria newly thrown off by your companions in the pool. Dilution is of great value here. A stream of fresh or purified water entering the pool with sufficient force to produce a current speedily dilutes the offensive matter and carries it to the outlet of the pool. The great dilution lessens your danger of infection.

I do not mean, however, to suggest that it is not worth our while to attempt to keep the bacterial count in our swimming pools as low as we can by the use of other agents. Where continuous dilution is not practicable chemical sterilization must, of course, be depended upon. Many of the older pools are constructed to operate on the fill-and-draw principle and have no provision for the purification and re-utilization of the water.

To my mind the re-filtration of pool water through suitable filters and the addition to the water of proper germicides offer great advantages. There is great saving in water, great saving in heat, the appearance of the water, its color and turbidity, are greatly improved and we have an abundance of purified water for dilution purposes. The capacity of the re-filtration plant ought to be sufficient to change the volume of water in the pool during the time the pool remains open except in very large pools. The San Francisco board of health requires at least 150 gallons of fresh water per user and the pool water must be changed to keep within the limit.

Where a pool is emptied one or more times a week the cost of the water required is often considerable, and when the tank is filled, the water is too cold and must be brought to the required temperature. If water can be circulated through an insulated filter, treated with alum to assist in the filtration and with some other germicidal agent to reduce the bacterial count, it can be returned to the pool with very little loss of heat, and the cost of operation is reduced to the cost of running the pump plus the cost of chemical or other treatment, depreciation and repairs. An example of this sort of saving may be seen in the following schedule of operation costs of the pool at the Evanston, Illinois, Y. M. C. A. as prepared by Mr. W. Lee Lewis of the Evanston board of health, Table 1.

Evidently the Evanston Y. M. C. A. plans to pay the same amount for the chemical sterilizer used as it did under the old system of operation. The results should, naturally, be more satisfactory.

Most swimming pool operators are agreed that refiltration of pool water is capable of effecting a money saving and in addition

renders the water clear, and of lessened color. There is less agreement as to what germicidal agent is most desirable. The necessary degree of bacterial freedom is not established. The water supplied to the swimming tank should be of good quality. Theoretically it should be kept fit to drink, because more or less water is usually taken into the nose or mouth. Relatively large amounts are often swallowed by those who are learning the art of swimming As a matter of fact the continuous pollution and bacterial multiplication make it very difficult to maintain the water in sufficiently pure condition to recommend its use as a beverage.

TABLE 1

Comparative annual costs of operation of Y. M. C. A. swimming tank under old and new system, Evanston, Illinois

	OLD SYSTEM CHANGED ONCE A WEEK	NEW SYSTEM CHANGED ONCE IN 3 MONTHS
Cost of water, 51,980 cu. ft. in year....	$348.00	$42.00
Heating new water*.....	183.04 (52 times a year)	14.08 (4 times a year)
Power for circulating pump†.....		200.00
Total cost per year.....	$531.04	$256.08
Actual saving per year‡.....	274.96	

* Calculated for use of Pocahontas mine-run soft coal at $4.40 per ton, averaging about 14,700 B.t.u. per pound and allowing an efficiency of boiler at 60 per cent.

† Pump driven by 2-horse power motor running ten hours daily for six days in the week, fifty-two weeks per year.

‡ This apparent saving could be applied to the cost of the extra equipment needed under new system. In the case of the Y. M. C. A. this equipment cost $1,600, which can be paid for in approximately six years by the saving in cost of the new over the old method.

You will all agree with me when I say that the location of the sampling point makes a great difference in the results. Leaving out of consideration the differences in the water from different parts of the tank, we would expect to find fewer bacteria in the effluent of the purification plant than in the effluent from the pool. The real test is the quality of the pool water. And the pool water will by no means remain constant in its content of bacterial flora. Because a test showed the apparatus to be giving satisfactory purification of the water three months ago, is no proof that it is behaving as

it should today. The operator should know the condition of his pool. He should have frequent examinations made. It is contrary to good ethics to advertise that the water of a pool is better than the city's drinking water supply unless the quality of the water in the pool is actually better. The test should not be the condition of the effluent from the purification plant, because a small quantity of water of very low bacterial content may be obtained from the purifiers and that quantity may be entirely insufficient to effectively dilute the water which has been grossly contaminated.

Levine (3) has remarked that the methods used by different investigators have been strikingly unlike. The tests for gas formation have been made in dextrose and lactose broths and in lactose bile. Various combinations of gelatine and plain and lactose litmus agar have been adopted for counting the bacteria. My personal preference is for the use of litmus lactose agar at 37°C. for twenty-four hours, plain agar at 20°C. for forty-eight hours, and lactose broth in 1 and 10 cc. quantities at 37°C. The need of a standard procedure is obvious. Each sort of medium yields different numbers of colonies if kept under different conditions. For example, our counts on 20° agar plates would seem very high if they were compared with the counts on the same sort of agar incubated at 37°C. This makes it almost impossible to compare the numerical results of any two investigators.

In general it may be said that the lower the bacterial counts the more satisfactory the condition of the water. The colon bacillus should certainly be absent from the majority of 1 cc. platings. The 37°C. count should be regarded as more significant than the 20°C. count since it presumably represents the organisms that prefer the warmer temperatures and are not typical water organisms.

Disinfectants. Norton (12) and others have demonstrated that the bacterial purification effected by a sand filter is not always sufficient. Other agents are therefore employed. Those most used are copper sulphate, chlorine and its compounds and the ultra violet rays. Ozone might be used, but I do not know of an installation. On account of its demonstrated efficiency, chlorine in its various forms seems to be preferred by most health officials. The ultra-violet ray is preferred by those who have a prejudice against the use of chemicals. Copper sulphate is the choice of others who desire to avoid the odors and tastes associated with overdoses of chlorine.

It is interesting to note that Thomas (13) does not hesitate to say that calcium hypochlorite is "out of the question" for swimming pools. Levine (3) says it "cannot be employed efficiently for continuous disinfection." On the other hand Rettger and Markley (14) say that the use of copper sulphate has "fallen into disrepute" and Stokes (15) says that "in moderately polluted water, the fermentative bacteria are not destroyed" by one part of copper sulphate in 100,000 parts of water. The great number of investigators seem to have used hypochlorite and to have been successful in using it.

Regarding the poisonous properties of these chemicals, it should be said that they are both harmless within reasonable limits. The taste of either is sufficient to prevent its use in pools in sufficient quantity to be injurious. Pasteur is quoted by Kraemer (16) as saying that it is almost impossible to take a dose of copper salts large enough to cause death, both from their horrible taste and the violent vomiting produced. Kraemer reports that one observer took from 10 to 20 mgms. of copper sulphate every day for eighty days and another observer every day for fifty days without any apparent ill result. Assuming that a pool is treated with one part per million of copper sulphate and that all the copper sulphate remained in solution, which it does not, a swimmer would have to swallow from 3 to 6 gallons of pool water to get the amount of copper sulphate which these men took every day. The most incautious beginner would not swallow so much as this.

There has been some notion that the irritating effect of the small quantities of bleaching powder used in pools may be injurious, and that there may be some effect on the teeth. Roberts (17) says, however, that the occasional application of hypochlorite in small quantities and high dilutions to the mucous membranes could not be other than beneficial.

The complaints of the taste, odor and effects of hypochlorite sometimes have a humorous twist. Kellogg (18) mentions that complaints usually begin to come in before the apparatus is installed. The complaints usually come from people who have read of the installation in the papers. Injury of delicate fabrics and even bleaching of the hair are claimed at times. This play on the imagination of these people who are afraid of chemical treatment is no new thing to water works men who will remember the case of a well-known water company which received complaints of the chlorinous odor and taste of the water a full three weeks before the appara-

tus was received. We have had such complaints of our swimming pools when we had not treated the water with chlorine for three months and in fact the apparatus was in New York undergoing repairs. Dr. Newhall, of Denver, and others have written me of similar experiences with the users of pools under their supervision.

The use of ultra-violet ray treatment of swimming pool water is reported to be very efficient. Its chief draw-back is its high installation and upkeep costs. It is preferred by those who wish to advertise that the water of their pools contains no added chemical. Inasmuch as an essential feature of this treatment is thorough and repeated exposure of the water to the ultra-violet light, any turbidity in the water renders the purification less effective. For this reason it is customary to use alum treatment followed by filtration.

I have reports of occasional accidental overdosing of soft waters with alum with consequent complaints of irritation of the eyes. Although alum treatment of water is good practice, it is nevertheless a chemical treatment. The statement that the water contains no added chemical is quibbling since there is calcium sulphate in the water that was not there before the purification. The apparatus has the advantage of being practically automatic, requiring no particular skill and being free from the possibility of overdosing.

From the results of Levine (3) and Thomas (13) as well as some work of my own, I feel sure that the copper sulphate treatment of pools *can* be satisfactory. The evidence of Burrage (9), Lewis (19), Rettger and Markley (14) Lyster (20), Ravenel (21), Bunker and Whipple (1), and others, as well as our work at the State University of Iowa, convince me that *chlorination* can successfully keep a swimming pool in sanitary condition. The ultra-violet ray has shown itself capable of yielding the desired purification.

Choice of disinfectant. All of these methods, then, being satisfactory under proper conditions, the selection of the method to be applied should be based upon the character of the pool water, the prejudices of the bathers and the funds available, as well as other special conditions.

To begin with, the use of alum removes a certain amount of the alkalinity each time the water is treated. With soft waters the natural alkalinity is very soon exhausted, since it is not advisable to reduce the alkalinity to less than 5 or 10 parts per million. With such waters lime, soda ash or sodium bicarbonate must be added. The water supply which we use contains about 300 parts per million of alkalinity

and very seldom runs down below 200 parts, since we are constantly adding fresh water to replace that used in washing the filters, etc. The need of careful supervision of the addition of alum does not concern us much, locally, but the user of soft water must watch the alkalinity of his water carefully lest some undecomposed alum in the pool water cause complaints. Sedimentation basins are useful in preventing the precipitation of alum in the pool when high filter rates are employed.

Hard water containing the bicarbonates of calcium and magnesium tend to throw down the copper from copper sulphate as a precipitate, probably of the hydrate. This might give the water a bluish color and turbidity. Organic matter and free carbon dioxide tend to prevent the precipitation of the copper or to retain it longer without sedimentation. The first practical use of copper sulphate was about 1902, when Moore (22) used it for algae removal from the Virginia water-cress beds. Caird (23), Quick (24), and Bado (25) and many others have found it very efficient as an algicide. In open air pools this property is of importance in addition to the bactericidal properties. The usual method of application is to spray a solution of copper sulphate on the surface of the pool, or to put a weighed amount of the crystals in a bag which is thrown into the pool to be dived for or dragged around the pool until the crystals are dissolved.

In some experiments of ours at a time when our chlorinators were out of commission I used a different procedure. I added the copper sulphate with the alum before the water entered the filter. Ellms in 1905 (26) reported that he had used this method with success and claimed that the increased concentration of the copper on the surface of the filter was advantageous. About the same time Clarke (26) at Lawrence had tried similar experiments with the experiment station filters and reported that the efficiency of the filters was slightly reduced. It should be remarked that the filters Ellms used were mechanical and those that Clarke used were of the slow sand type. The lessened efficiency in the latter case was due to the interference with the biological processes in the slow sand filter. Some German experimenters have claimed that most of the spore-forming bacteria are killed in passing through a sand bed whose top layers show a considerable concentration of precipitated copper.

Results. In our experiments we found that, compared with the

ratio when chlorination was used, the copper sulphate was more efficient in destroying the organisms growing at 20°C. than in destroying those growing at 37°C. While our counts at 37°C. did not go above 500 per cubic centimeter, nevertheless a greater percentage approached 500 than when we used chlorine. We used only about one-fifth of a part in 1,000,000 of copper sulphate per day, but that amount seemed quite effective. In comparing these results with Levine's (3) it should be remembered that his counts are 37°C. counts taken at the deep end of the pool, while our counts were made at 37° and 20°C. and were taken at the shallow end only a few feet from the inlet.

During this year, it is our plan to alter our practice somewhat by taking samples midway of the pool, while repeating enough tests from time to time under the old system to keep the results comparable, and in addition to take direct samples of the purified water.

The literature on calcium hypochlorite is extensive. Its use was given wide publicity by Jennings in 1908 (27) although the use of hypochlorite and similar compounds had been tried before with success. A survey of the method by Johnson (28) will be found interesting. Burrage (9) used hypochlorite at Purdue in 1910 to purify the swimming pool water. His method was to sprinkle the powder directly onto the surface of the pool water and allow the powder to sink. This method is unsatisfactory, since the tell-tale odor of the powder remains in the room, which renders it objectionable to the bathers. Some powder also remains on the surface, which is unsightly and likewise objectionable from the local concentration of odor and taste. Dragging the powder enclosed in a bag over the surface of the water is objectionable for like reasons. If the bag be weighted the objectionable odor in the room is eliminated. It has been suggested by Bunker (29) that the best way of applying the powder is to draw the weighted bag through the water by a series of sharp jerks. At each jerk a little cloud of the powder is thrown into the water at the bottom of the pool. Of course, javel water or a suspension of the hypochlorite may be injected into the circulation system of the pool.

Buswell (30) tried to avoid the odor of the chlorine and the inaccuracies of administration at Columbia University by adopting the use of a saturated solution of chlorine in water. The solution was prepared by bubbling chlorine gas through a series of 5 gallon bottles of water.

It may be that a given excess of chlorine is objected to more earnestly in a pool because of the large quantity of water and the persistence of the heavy odor of chlorine. Salt in a water serves somewhat to disguise the objectionable taste. Roberts (17) suggested the use of enough common salt to render the water of a pool a solution of about 0.9 per cent salt, usually called a physiological salt solution, urging the disguising of the odor of the germicide. The only organization that I know of which adds salt to the water of the pool is the Deseret Gymnasium at Salt Lake City, Utah.

In using liquid chlorine with the usual apparatus at the State University of Iowa, we tried at first to add the gas continuously and very slowly. This was not successful. We then added the chlorine in larger doses, early in the evening and treated with a rather large dose on Saturday night. This procedure was quite successful in reducing the trouble. We cannot give the exact rates used because the quantities involved were very small and we had no platform scales.

The results shown in table 2 are the range of bacterial counts on the two state university pools. They are reported according to the number of days on which the counts fell into certain numerical groups.

TABLE 2

Tests at the swimming pools of the State University of Iowa

POOL	CONDITIONS	RANGE OF BACTERIA LITMUS LACT. AGAR.						RANGE OF BACTERIA NUTRIENT AGAR								
		DAYS 0 PER C. C.	1–10 PER C. C.	11–50	51–100	101–500	NO. PLATINGS	DAYS 1–100 PER C.C.	101–500	501–1000	1001–10,000	10,001–20,000	20,001–30,000	NO. PLATINGS	GAS FORMERS, DAYS IN 1 C. C.	ACID COLONIES, DAYS IN 1 C. C.
Women's	Filter alone	1	17	5	0	1	24	3	7	5	7	3	1	26	3	1
	Filter and Cl	7	20	9	1	5	42	0	3	1	24	10	7	45	0	0
	Filter and $CuSO_4$	0	2	11	5	61	79	1	0	0	34	27	20	82	0	0
Men's	Filters alone	1	23	2	0	0	26	0	4	4	13	6	2	29	7	2
	Filters and Cl	16	19	5	4	1	45	0	0	4	20	11	10	45	0	0
	Filters and $CuSO_4$	2	11	8	10	47	78	0	0	1	49	23	11	84	0	0

Period covered, January 27 to August 24, 1916.
Women's pool emptied May 19, 1916; men's, May 27, 1916.

TABLE 3

Swimming pools

STATE	CITY	MAINTAINED BY	CAPACITY	GALLONS PER USER PER DAY	DIMENSIONS				TEMPERATURE °F	TIMES EMPTIED AND CLEANED	PURIFICATION PROCESSES							USERS PER DAY	SOURCE
					Length	Width	Maximum depth	Minimum depth			Filters	Alum	Chlorine	Calc. Hypochl.	Copper sulph.	Ultra-violet ray	Other		
			gallons		*ft.*	*ft.*	*ft.*	*ft.*											
Alabama	Mobile	Y. M. C. A.			50	22	6	4	70	Once a wk.							Circulation	150	City
California	Berkeley	U. of C. (Men)	650,000	3,250	232	76	10	3	65–68	4 times year				+			Circulation	200	City
California	Berkeley	U. of C. (Women)	131,000	749	75	40	8½	3	70–72	4 times year				+			Circulation	175	City
California	Palo Alto	Stanford (Men)	230,000	2,300	100	40	9	3½	60–72	Every 3 wks.	+	+		+	+		Open air	100	Stream
California	San Francisco	Lurline Baths	325,000		140	65	9	2	79–80	2–4 times wk.	+						Electro-chlor.		Ocean
California	San Francisco	Y. M. C. A.	115,000	144	85	25	9	3½	72	2 times wk.			+					800	Ocean
Colorado	Denver	Y. M. C. A.	55,000	157	60	20	8½	3½	80	4 times yr.	+	+		+				350	City
Connecticut	New Haven	Yale University	150,000	400	75	30	11	5½	78	1 time week				+				350–400	Well
Connecticut	Waterbury	Y. M. C. A.	33,000	189	40	18	6½	2½	70	4–6 times yr.	+	+						150–200	City
Illinois	Chicago	Cent. Y. M. C. A.	65,000	173	66	22	8½	3½	75	Every 1–2 dys.	+							250–500	City
Illinois	Chicago	Div. St. Y. M. C. A.			60	25	8	3	72–75	Every 3 days	+	+						135	City
Illinois	Chicago	Y. M. C. A. Col.			60	24	7	6	78	Every 2–3 dys.	+	+						100	City
Illinois	Evanston	Y. M. C. A.	76,000	506	60	25	8½	3½	76		+	+		+				150	City
Illinois	Peoria	Y. M. C. A.	62,000	620	60	20	8½	3½	78	4 times yr.	+			+				100	City
Illinois	Rock Island	Y. M. C. A.	60,000	240	60	20	7½	3	75–82	4–12 times yr.	+	+		+				200–300	City
Indiana	Evansville	Y. M. C. A.	75,000	300	75	25	7½	3½	84	2 times wk.								250	City
Indiana	Indianapolis	Y. M. C. A.	58,000	580	60	20	8½	4½	68–70	2 times wk.				+				100	City
Indiana	South Bend	Y. M. C. A.			60	24	8½	3½	75	1 time wk.				+				100	City
Iowa	Ames	Ia. State Col.	90,000	900	60	30	7½	3		Irreg.	+				+			<100	City
Iowa	Burlington	Y. M. C. A.	60,000	1,500	60	20	8½	3½	76–89	1 time wk.	+	+						25	City
Iowa	Cedar Falls	St. Teachers	48,000	240	55	20	6	4	78–82	1 time wk.					+			200	City
Iowa	Cedar Rapids	Y. M. C. A.	50,000	250	49	20	7	4		1 time wk.				+				200	City
Iowa	Clinton	Y. M. C. A.	24,000	320	33½	17½	7½	4½	78	1 time wk.				+	+			75	City

Iowa	Council Bluffs	Y. M. C. A.	20,000	571	40	15	7	3½	78	2 times wk.								35	City
Iowa	Davenport	Y. M. C. A.	55,000	200	60	20	7½	3	80	6-9 times yr.	+	+			+			100-450	City
Iowa	Des Moines	Y. M. C. A.	54,000	164	60	20	8	4	78	3 times wk.				+				204-455	City
Iowa	Des Moines	East D. M. H. S.			40	20	7½	4	Irreg.	2 times wk.	+	+						25-100	City
Iowa	Dubuque	Y. M. C. A.	48,000		60	18	8½	3½		Irreg.	+	+		+					City
Iowa	Ft. Dodge	Y. M. C. A.	35,000	255	60	18	8½	3½	72-80	2 times wk.					+			125-150	City
Iowa	Iowa City	I. C. High School	25,000	1,667	40	20	5	3½		2 times wk.				+				15	City
Iowa	Iowa City	S. U. I. (Men)	89,100	445	60	30	8	4	76	3-4 times yr.	+	+	+		+			200	Well
Iowa	Iowa City	S. U. I. (Women)	61,200	254	60	24	7½	3 2/10	84	3-4 times yr.	+	+	+		+			225	Well
Iowa	Keokuk	Y. M. C. A.	55,000	315	51	23	8	4	75-82	2 times wk.								150-200	Well
Iowa	Ottumwa	Y. M. C. A.	45,000	300	50	24	7½	4½	80	1 time wk.				+				150	Well
Iowa	Sioux City	Y. M. C. A.	8,547	85	30	12	6	3	76	2 times wk.								100	City
Iowa	Waterloo	Y. M. C. A.	40,000	267	40	20	6½	4	70-76	2 times mo.								150	City
Kentucky	Louisville	Y. M. C. A.	97,000	277	75	30	8	4	76-80	1-2 times wk.	+	+		+				300-400	City
Kansas	Lawrence	U. of K.	50,000	333	50	20	8	8	76-78		+							100-200	City
Maryland	Annapolis	U. S. N. Acad.	160,000	400	80	60	5½	3½	72-75	2 times mo.	+		+					400	Well
Massachusetts	Cambridge	Y. M. C. A.	45,000	300	60	20	7½	3½	72	2 times yr.	+				+			150	Well
Massachusetts	Springfield	Int. Y. M. C. A. Col.	75,000	250	60	24	8	4	68-75	1 time yr.	+	+		+	+			300	Well
Massachusetts	Springfield	Y. M. C. A.			75	25	7	3½	74		+	+				+		200	City
Michigan	Ann Arbor	U. of M. (Women)					5	3½	70-74	Every 3 wks.				+			Circulation	10-40	City
Michigan	Detroit	Y. M. C. A.	100,000	333	75	30	8	5	76	Every 3 wks.	+	+				+		300	City
Michigan	Grand Rapids	Y. M. C. A.	53,000	265	60	22	8	3½	75-80	Every 3 mo.	+	+			+			200	City
Minnesota	Minneapolis	Y. M. C. A.	30,000	120	35	20	5½	4½	72-75	2 times wk.				+				250	City
Minnesota	St. Paul	Church Club	52,000	963	50	25	8	3	78	6 times yr.	+	+			+			54	City
Minnesota	St. Paul	Wilder Baths	90,000	189	70	30	8	4	78	2 times wk.	+			+				460	City
Minnesota	St. Paul	Y. M. C. A.	80,000	457	75	25	8	4½	72-74	2 times wk.					+			175	Well
Missouri	Columbia	U. of Mo.	40,000		50	20											"Antiseptic"		City
Missouri	Kansas City	Y. M. C. A.	35,000	187	45	20	7	3½	76-80	3-24 times yr.	+	+		+				75-300	City
Missouri	St. Louis	St. Louis U.			100	50	20	4		2 times wk.								100	City
Missouri	St. Louis	Cent. Y. M. C. A.	58,000	290	69½	22	6½	4	76-80	1-3 times wk.				+				200	City
Nebraska	Omaha	Y. M. C. A.			60	20	8	3½	78	2-3 times wk.								100-125	Well
New York	Buffalo	Cent. Y. M. C. A.	54,000	270	60	20	8	4	74		+	+		+				200	City
New York	New York	Coll. City, N. Y.	125,000	139	100	28	8	5	74	1 time wk.	+							900	City
New York	New York	23d St. Y. M. C. A.	55,000	183	48	24	7½	4½	65-70	1 time wk.								300	City
New York	New York	W.side Y. M. C. A	60,000	100	60	21	8½	5	74	2-3 times yr.	+	+				+		600	City
Ohio	Cincinnati	Y. M. C. A. (old)			40	18	6	3	70-78	3 times wk.								100-300	City

TABLE 3—*Concluded*

STATE	CITY	MAINTAINED BY	CAPACITY	GALLONS PER USER PER DAY	DIMENSIONS				TEMPERATURE °F	TIMES EMPTIED AND CLEANED	PURIFICATION PROCESSES							USERS PER DAY	SOURCE
					Length	Width	Maximum depth	Minimum depth			Filters	Alum	Chlorine	Calc. hypochl.	Copper sulph.	Ultra-violet ray	Other		
			gallons		*ft.*	*ft.*	*ft.*	*ft.*											
Ohio	Cleveland	Case S. A. S.			60	29	8	4	76–78	2–3 times mo.	+	+	+					<100	City
Ohio	Cleveland	Cent. Y. M. C. A.	85,000	188	75	25	8	4	76	1 time wk.	+	+		+				400–500	City
Ohio	Columbus	O. S. Univ.			40	20	6	3	76	Daily								400	City
Ohio	Columbus	Y. M. C. A.	50,000	250	58	18	6½	2½	78	3 times wk.				+				200	City
Ohio	Dayton	Y. M. C. A.			60	24	7½	4	78	6 times yr.	+	+				+		200	Well
Ohio	Toledo	Y. M. C. A.	50,000	333	60	20	7	4	80	1 time wk.				+				150	City
Pennsylvania	Philadelphia	Cent. Y. M. C. A.	96,000	320	75	25	8½	4½	76	1 time mo.	+				+			300	City
Pennsylvania	Pittsburgh	E. Liby. Y.M.C.A.	60,000	240	60	30	8½	3½	76	1–2 times wk.				+				250	City
Pennsylvania	Pittsburgh	Hilltop Y.M.C.A.					8½	3½	76	3 times wk.	+	+						60	City
Pennsylvania	Pittsburgh	Lawrenceville Y.	50,000	500	60	20	7½	4½	76–78	1 time wk.							"Chemicals"	100	City
South Carolina	Charleston	Y. M. C. A.	67,265		60	20	8	4	79–84	1 time wk.	+	+		+				—	City
Texas	Galveston	Y. M. C. A.	25,000	250	37	20	11½	4	—	2 times wk.					+			100	City
Utah	Salt Lake City	Deseret Gym.	88,000	147	60	30	8½	5½	78	1 time wk.	+			+			Salt	600	City
Virginia	Richmond	Y. M. C. A.	40,000	200	60	20	7	4	68	2–3 times wk.	+	+		+				200	City
Washington	Spokane	S. A. A. Club			44	20	8	3	68	3 times wk.								100	City
Washington	Spokane	Y. M. C. A.	35,000	171	48	18	7½	3	75	2 times wk.								50–300	City
Wisconsin	Appleton	Y. M. C. A.	50,000	500	60	20	7½	3	74	4 times yr.	+	+		+				100	City
Wisconsin	Menomonie	Stout Inst.	100,000	2,000			8	3	78						+		Circulation	50	Well
Nova Scotia	Halifax	Y. M. C. A.	27,000	216	40	18	8	4	74	1 time wk.				+				50–200	City
Ontario	Montreal	Y. M. C. A.	80,000	229	75	25	9	4	70	1 time wk.	+							350	Well
Ontario	Ottawa	Y. M. C. A.	30,000	120	40	18	8	4	68	1 time wk.							Half-filled daily	250	City
Quebec	Quebec	Y. M. C. A.	56,000	1,400	50	25	8	3	70	1–2 times wk.								40	City

NOTE.—A preliminary shower bath is required at each of these pools.

The test with the filter alone should really not be compared with the two other tests since the pools were filled the first time near the end of the first semester and were used only by the instructors until a few days before chlorine treatment commenced. You will note, however, that gas and acid formers were in the pool water. Then note that there were no gas and acid forming bacteria found on 1 cc. quantities during the period when we were using copper sulphate and liquid chlorine. At the present time, still using copper sulphate because our chlorinators are not connected as yet, we are finding no gas formers in 10 cc. of pool water.

General practice. Within the last two months I have been sending out questionnaires relating to swimming pool practice. I was especially anxious to know what methods of purification were used, what temperature was maintained and how many gallons of water each pool contained for each user in a single day. Table 3 contains the data for 81 pools.

A survey of this data shows the following:

Pools reporting	81	
Pools using filters	41	
Pools using filters and alum	29	
Pools using liquid chlorine	5	38
Pools using calcium hypochlorite	33	
Pools using copper sulphate	16	
Pools using chlorination and copper sulphate combined	5	
Pools using ultra-violet rays	4	
Pools using no treatment	13	
Average temperature	75.7°F.	
Average capacity	77,000 gallons	
Average number users in 1 day	214	
Average number gallons per user first day	486.3 gallons	

SUMMARY

1. The construction of a swimming pool should render it easy to clean the pool and its surroundings and to keep them in that condition.

2. The convenience of the users should be considered and it should be made easy for them to do their part in keeping the pool sanitary.

3. Users should be inspected and required to bathe thoroughly; to avoid coughing, spitting and urinating in the pool, and to avoid the carrying of dirt of any sort into the water upon their persons.

4. Suits if worn, should be light-colored and should be kept clean.

5. There is need of some reasonable bacterial standard for pool water and there should be a more uniform analytical procedure as well.

6. The fresh, vigorous bacteria newly thrown off by your neighbors in the pool are most dangerous to you. They can be rendered less dangerous by rapidly diluting the polluted water with fresh or re-purified water.

7. Re-filtration effects a considerable saving in water and heat and supplies a clear water. It is not satisfactory for providing a sufficiently pure pool water.

8. Copper sulphate, chlorination and the ultra-violet ray are capable of purifying the water.

9. The ultra-violet ray apparatus is expensive to purchase and operate.

10. Chlorination has been more efficient than copper sulphate in our experiments, and is more widely used.

11. Copper sulphate is employed to avoid the odor and taste of the chlorine compounds.

I wish to acknowledge the assistance of Harold Barber and Frank Kennan, who have carried out the operation of the purification devices and the examination of the water of the pools at the State University under my direction.

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THE WATER SUPPLY OF THE QUAD CITIES[1]

By Martin R. Carlson[2]

The Quad Cities (Davenport, Iowa, Rock Island, Moline and East Moline, Illinois), offer to the water works man a good field for observation. In our midst we have six distinct water departments —four supplying filtered Mississippi River water and two well water. Three of the four use mechanical filters and the fourth pressure filters. In East Moline, Illinois, and Bettendorf, Iowa, they use deep-well water, pumped into elevated tanks.

Davenport. Unlike the Moline, Rock Island, East Moline and Bettendorf plants, the Davenport water works is owned by a private corporation operating under a franchise. The source of supply is the Mississippi River the intake being located on the north side of the main channel. The method of operation is by gravity from river to screen chamber and intake well; pumping from intake well to settling basin; pumping from settling basin through filters to low-service mains and elevated storage reservoir; pumping from storage reservoir into high-service mains. The water supplied to the low-service mains is pumped twice; the water supplied to the high-service mains is pumped three times. The total quantity is about 4,000,000 gallons per day, of which about 1,500,000 gallons are pumped into the high service mains.

The works were built in 1873 and have been under the same management since that time. The main idea in the mind of the management has been "service first." This is shown in many ways. For instance, filters were installed in 1891, which was early in the history of mechanical filters, and modern improvements such as large sedimentation basins, air wash and sterilization have been added as soon as shown to be practicable. Then there is the great advantage of two pumping stations in time of large fires, the reservoir pumping station supplying water down hill for fires in mercan-

[1]Read before a joint meeting of the Iowa and Illinois Sections on October 11, 1916, Moline, Ill.

[2]Mayor of Moline.

tile and manufacturing districts to assist the main pumping station and reduce the rate of filtration. All hydrant branches have auxiliary gate valves. More than 22 per cent of the mains in the distribution system are 12 inches in diameter and larger. The mains less than 6 inches diameter are between 3 and 4 per cent of the total mileage. There are 100 miles of mains and 975 public fire hydrants.

The last franchise was granted in 1913 and extends for twenty-five years from January 1, 1914. It provides for proper regulation, character of fire streams, elimination of 4-inch mains, location or relocation of fire hydrants, appraisal of property, option to purchase, testing of meters, rates, annual statement of books and accounts, payment of taxes, character of water and service, and a large amount of specified new construction to be completed in three years. Before granting a franchise a special election was called to decide if the voters desired to buy or to build a water works. The voters did not, and then the franchise was submitted to the voters and adopted.

Extensions of mains are made by order of the city council, when there is an average of three consumers to each 400 feet of main, the city council ordering at least nine hydrants per mile of extension. All the expense of extensions of mains is borne by the water company, of course.

Because of the unusual facilities of both the water and fire departments for fighting fire in Davenport, the underwriters have placed the city in Class 2 for rating purposes. Davenport had 9360 water consumers on January 1, 1916, of which number 7225, or 77 per cent, were metered. The daily pumpage per capita is 80 gallons.

Since the new franchise was granted the company has laid 15 miles of new distributing mains, laid a 24-inch force main from the river pumping station to the business district; rebuilt its river pumping station and installed there a new 10,000,000 gallon, triple-expansion, vertical, crank-and-flywheel, high-duty pumping engine, two additional 250-horse power water tube boilers and stokers. A new 5,000,000-gallon, turbine-driven, centrifugal pump has been placed in the reservoir station.

The Davenport reservoir is located 150 feet above the business district, producing about 65 pounds pressure. This is the average pressure for domestic purposes on the low service mains. The reservoir pumping station stands on ground as high as any in the city

and 40 pounds pressure is carried on the pumps for domestic purposes. This gives from 40 to 100 pounds, on the high-service mains, which cover all levels between that of the business district and that of the reservoir.

When there is a fire on the low-service, a valve on the pipe connecting the low-service mains with the reservoir is closed by the employees at the reservoir. The river pumping station then pumps directly into the low-service mains, carrying about 90 pounds pressure in the business district and 100 pounds at the pumping station. In case it is desirable, some water may be pumped from the reservoir by the reservoir pumping station into the low-service mains, there being a valve for this purpose in the reservoir pumping station.

In case of fire on the high service, the speed of the pumps at the reservoir is increased to maintain 70 pounds pressure at the pumps, producing from 70 to 130 pounds at the hydrant, according to location. Both pumping stations are operated continuously by three crews, each working eight hours.

The original works consisted of 20 miles of mains, a twin-cylinder horizontal engine geared to a long-stroke, slow-moving, horizontal pump, which lifted water from the river and pumped into the mains. The engine, as well as many of the valves, hydrants and special castings, were built by the late Michael Donahue, of Davenport, who obtained the original franchise to build the water works. Mr. Donahue's son, Colonel James P. Donahue, is today secretary and treasurer of the company. Thos. N. Hooper was associated with Mr. Donahue from the beginning of construction and is still vice-president of the company.

Rock Island. In Rock Island the water is taken from the main channel of the Mississippi river through two intake pipes, a 20 and a 30-inch, and flows into a well at the pumping station, which is 2100 feet from the channel. It is then pumped through a 16-inch main to the settling basins, 1¼ miles distant and 175 feet above city datum, and flows from the settling basins to the filters; thence from the filters to the clear-water basins and reservoir. From the reservoir, it is conducted to the city level through a 20-inch main, under 55 to 60 pounds pressure. There is a 500,000-gallon standpipe at the reservoir, the balcony of which is 125 feet above the ground. This is used for the bluff service or high line. The pump to supply the standpipe is installed at the filter plant, and is electrically driven.

When the water works was first installed in 1874, direct pressure was used, and this was continued until 1900. In the fall of 1897 the city began two settling basins, three slow sand filters of 1,000,000 gallons capacity each, and a reservoir of 8,000,000 gallons capacity. This improvement was completed in 1900, and since that time the supply has been by gravity from the reservoir. In 1910 it became necessary to enlarge the filtering capacity and the area required was so great for the slow sand filters that mechanical filters were adopted. They now have a plant with a capacity of 6,000,000 gallons in twenty-four hours installed in one of the old slow sand filters, and the two other filters are used for clear-water basins, and, with the reservoirs proper, altogether hold about 12,000,000 gallons of filtered water. The two settling basins, of 2,500,000 gallons each, are still used for that purpose.

The coagulant is applied to the raw water at the inlet to the basins and is given a period of six to twelve hours. After passing through the basins, the treated water is conducted to the filters in a 36-inch conduit, into which liquid chlorine is applied about 25 feet before entering the filters. There are six filters of 1,000,000 gallons capacity.

At the present time there are about 65 miles of mains in Rock Island, but a contract has recently been let for 6 miles more to be laid this year. Most of this work is necessary to supply a newly annexed territory to the south, and includes a 1,000,000-gallon stand-pipe for high pressure, to be placed about 125 feet above the ground. An electrically driven pump will be used to fill this tank.

There are about 600 fire hydrants, and the department is making a practice of placing a hydrant on each corner of each block and placing a gate valve on the branch to each hydrant. This is a recognized improvement in hydrant installation, as repairs to the hydrant can be made without shutting off the main. All new hydrants have an outlet for steamer nozzle and two outlets for a $2\frac{1}{2}$-inch nozzle. Another commendable practice is that of laying large mains about every five blocks and cross-connecting them with not less than 6-inch mains.

Rock Island has about 6000 water consumers, with a revenue of about $73,000 annually. All schools, the Y. M. C. A., and hospitals and charitable institutions are given water free of charge. The meter rate is from 20 to 6 cents for each 100 cubic feet, with a minimum charge of $9. The minimum flat rate for residences is $9.

Government Arsenal. On the Arsenal Island, there are medium size settling basins and gravity filters, very similar to the Moline plant.

Moline. In the city of Moline are found small settling basins and gravity filters. Alum is used as a coagulant and chlorine for sterilization. Prior to 1883 water was supplied to Moline by pumps in one of the local saw mills. During this year some enterprising citizens undertook the building of a private water company on the present location. The water was taken from the river and supplied to the citizens in its raw condition. In 1885 an agreement was reached with the water company for the taking over of the equipment by the city, and for thirty-one years Moline has been supplied with water by its own plant. From 1885 to 1903, raw Mississippi River water was in use. In 1903 mechanical filters were installed. At that time three 1,000,000-gallon units were placed in operation and since then two more have been added, giving Moline a filtration capacity of 5,000,000 gallons. The settling basins are very small, holding about 500,000 gallons, so baffled, however, that only a very small part is dead space. The clear-water reservoir holds 750,000 gallons. In conjunction with this a standpipe on the hill has recently been installed having a capacity of 500,000 gallons, making the filtered water storage 1,250,000 gallons.

The low-service equipment consists of centrifugal pumps, one 5,000,000-gallon and one 6,000,000-gallon, one unit being driven by a Kerr turbine and the other by either a water motor connected to the high-service pump or a high speed engine. Two intake pipes are used, one taking water from a slough to the rear of the plant, and the other taking water from the main channel.

The high-service equipment consists of a 10,000,000-gallon Epping-Carpenter pump, a 6,000,000 Holly-Gaskell, and a 5,000,000-gallon Deane, giving a total high-service capacity of 21,000,000 gallons. Venturi meters have been installed for determining the city consumption and boiler feed water consumption.

In 1911 a question arose as to the advisability of extending the raw water intake pipe 6 or 7 miles upstream so as to obtain a purer supply. Upon the recommendation of the Illinois State Water Survey, the project was dismissed and more important improvements at the water plant adopted. On the recommendation of a consulting engineer $164,000 in bonds were issued for the rehabilitation of the water works and distribution system. The improvements completed from this issue consist of new boiler equipment, new

stack, new pumps, new building, elevated tank, new mains and meters. These improvements were finally completed in 1915.

It is the plan of the water department to have every service in the city metered. At the present time about 1700 meters, or about one-third of the total services, have been installed. The total city consumption ranges from 3,500,000 to 5,000,000 gallons daily. For a city of 30,000 population we have about 5700 services and 68 miles of water mains.

AN INVERTED SIPHON IN A SUCTION LINE[1]

By Karl C. Kastberg

A feature of water works construction which presents elements of great concern to the designing engineer is the so-called suction line leading from the source of water supply to the pumping machinery. A statement of the natural phenomena responsible for the performance of liquids under these circumstances will be pertinent.

When a piston traverses the course of its component cylinder, whatever substance occupies the body of the cylinder must needs be displaced, and as the channel provided for its movement is usually that circumscribed by the pipe leading from the cylinder, there is no limit to which the fluid may be forced other than that set by the strength of the pipe to withstand the pressure and the power supplied behind the piston to deliver it. On the other hand, in all cases where the pump cylinder is at a higher elevation than the source of supply, there is a determinate limit to which any liquid will rise to fill the space vacated by the piston in its forward movement. The temperature of the liquid in a measure affects the operation of pumps, but inasmuch as the cases occurring in water works operation have to do with water only, and at temperatures varying only from 33° to 70°, this feature may be neglected.

The height to which water will rise to fill a chamber vacated by a piston is directly proportional to the pressure of the air, which in turn varies with the elevation of the station above sea level, being greatest at sea level and reducing gradually with the height. In terms most used by the engineer these relations are expressed in inches on the mercury barometer or in feet on the water barometer, a fixed ratio existing between the two. At sea level we have 30 inches mercury and 34 feet water pressure; at an elevation of 1000 feet, 28.94 inches mercury and 33.3 feet water; at 2000 feet elevation, 27.92 inches mercury and 31.6 feet water; at 10,000 feet ele-

[1]Read at a joint meeting of the Illinois and Iowa Sections at Davenport, Iowa, on October 10, 1916.

vation 20.93 inches mercury and 23.7 feet water. For practical consideration in the central states we can use the figures 28 inches mercury and 32 feet water. It is evident therefore that under no possible circumstances can a pump operate at a greater height than 32 feet above the water level, inasmuch as this is the height to which the air pressure will force water to rise under perfect conditions of vacuum.

There are other features entering into the problem which must be considered, all of which tend to reduce this height, viz: Loss of head due to friction of water flowing in pipes; entrance of air to the suction line through defects in material of which the pipe line is constructed and through defective joints; elements of reactionary forces due to the reciprocating motions of the pump plungers, and in a measure not thoroughly comprehended yet often neglected, the presence of entrained air or other gases found in water percolating through sand beds or filter galleries. This last feature often gives rise to much difficulty in operating pumping machinery and is not usually developed until after the plant is in operation, requiring expensive alterations or additional equipment to correct the difficulty.

Loss of head may be be considered and accounted for as in ordinary cases of water flowing through pipes, a corresponding reduction in height being made. For defects in pipe material and leaky joints the remedy is obvious, viz.: replacement and repair. Under no circumstances should a suction line be covered until by thorough test these defects have been developed and corrected. Water hammer and column reactions can be controlled by the proper regulation and operation of the pumps. Entrained air and gases may be collected in suitably arranged chambers above the suction line at intervals and relieved by adequate vacuum pumps.

The prime requisite in any suction line is that it should have a continuously ascending grade from the water source to the pump chamber. It sometimes occurs, however, by reason of the location of the pumping station with relation to the collecting system that this condition becomes impossible of fulfillment, and recourse must be had to other methods of accomplishing the same result.

A method becomes available in a form of an inverted siphon with proper equipment for removing collected air or gases from the high point in the siphon. To illustrate by a case in point we will briefly describe the installation of the inverted siphon in the collecting system of the Boone City water works, which was designed

and installed by the writer at Boone, Iowa, in the spring of 1911.

Two distinct systems of screened wells connected to cast iron suction mains were installed. One system followed the east bank of the Des Moines River for a distance of approximately 2000 feet, the wells being located in water-bearing sand and gravel and connected to an 18-inch cast iron main laid at a uniform grade of 0.1 per cent, beginning at an elevation of 2 feet above low water and terminating at the common header of both lines, at an elevation of 4 feet above low water. This header, together with the low-lift pumps, is located in a concrete pit approximately 24 feet in depth, and 300 feet from the river bank.

The second system, and the one in which we are more interested, is located in an island in the river, which it traverses for a distance of 800 feet. Wells similar to these on the land system are connected to the pipe line, all being equipped with hermetically sealed concrete manholes as a measure of protection during stages of high water. The open channel between the island and the mainland is 200 feet in width, the bottom being approximately 12 feet below the general level of the island.

The cast iron suction main was laid on a uniform grade beginning at an elevation of 1.60 feet above low water and ascending through a distance of 800 feet to a point opposite the water works station, to an elevation of 2.40 feet above low water. The distance from this point to the pump pit in the station is approximately 550 feet. An air chamber was provided by capping an 18 by 18 by 18-inch cast-iron tee, and dropping the main vertically to an elbow connection with the inverted siphon pipe under the east channel of the river. This pipe was laid to a carefully adjusted vertical curve to conform as much as possible with the general form of the river bottom.

A 2-inch galvanized iron pipe leading from the top of the air chamber and carried down and parallel with the siphon pipe crosses the channel and is connected to a wet vacuum pump in the pit building. The siphon and air pipe were banded together and carefully lowered to place from a pile trestle bridge, and bedded 4 feet below the channel bottom. Flash boards attached to the top of the pipe during the process of lowering forced the water in the stream under the pipe, eroding sand and gravel from below and materially expediting the operation of excavation for the pipe bed.

At low water stages the system at times operates under 16 to

18 inches vacuum, corresponding to approximately 20 feet hydraulic suction.

The plant has been in operation for five years and to date no trouble attributable to this feature of the installation has been experienced.

THE USE OF WATER METERS[1]

By J. C. Beardsley

Should all taps be metered? As a general proposition, no one will take issue with the statement that a measured rate is more just, more economical from the standpoint of both buyer and seller and more scientific, than any flat rate that can be devised. There may be apparently exceptional conditions, as in the Allegheny Mountain region or in the artesian well section of the Dakotas, where water is brought into the distribution mains under pressure, without pumping and therefor at low cost. Towns in these sections are usually small, with no very large consumers or considerable inequalities in consumption, so that flat rates do not work any great injustice; and the cost of water at the tap is perhaps negligible, while the cost of meters looms large in the eyes of the great majority of town legislators of those regions.

Even in these sections, however, some towns have drawn so heavily on their stored wealth of water that they have seen its exhaustion approaching and have resorted to meters, usually for all taps. Of these I now remember Staunton, Virginia; Bluefield and Princeton, West Virginia, and Aberdeen, South Dakota. At the last named, they got water in their mains at a pressure of 80 to 100 pounds from artesian wells for several years, but drew so heavily on it that it was finally reduced to zero and for four or five years past have had to resort to pumping. In most localities, water at the tap represents a considerable portion of the expense of the plant, and in these, it seems to me, there can be no sound argument against the use of meters on all services.

I do not think that today there is any doubt as to the advisability of metering all large consumers, such as manufacturing plants. It used to be common practice, especially in the smaller towns which were eager to attract such plants to their locality, to subsidize them

[1] Read at a meeting of the Central States Section at Cleveland, Ohio, October 11, 1916.

at the expense of the water takers, by giving them low flat rates or no rates at all; but this resulted in putting such heavy burdens on the water works that it is not now much in evidence. It is also usually considered advisable to meter buildings used for commercial purposes and for housing more than one or two families, as hotels, flats, tenements, etc., owing partly to the difficulty of assessing equitable flat rates on such premises and partly to the greater waste that usually occurs in them.

The metering of single dwellings of six to ten rooms, with sanitary conveniences—the homes of our average good citizens—is probably least profitable to the water works, as it is in these that the least waste occurs and it is possible to assess a more nearly equitable flat rate on them. But even in these, the few goats amongst the sheep may waste enough to pay for metering of all.

Small houses with one or two spigots are the sore spot in all water works. They are inhabited by a class which cannot pay an average rate and which, when it is deprived of water for non-payment, goes to its neighbor (if he is not metered). Poor building construction, ignorance and bad personal habits, all tend to cause flagrant waste but most superintendents think long before they make up their minds to meter such a locality. When it is realized, however, that ten years' normal supply can be and often is wasted in one collection period, through one service, I believe it will be clear that the meter is the proper remedy, even if it has to be installed at the curb, as is usually the case with this class of services.

To conclude this part of the subject I will quote from the paper on water rates, read at the Rochester convention in 1911, by Geo. G. Earl:

> **The water works system that attempts to work on a flat rate schedule cannot possibly do even approximate justice between its consumers, even those consumers who have the same rates applied to the same fixtures and conditions, because the personal element enters and cannot be eliminated, and the flat rate which averages right for a large number of families will be a rank injustice to the careful consumer, and an equal injustice to the water purveyor in the case of the careless consumer.**

Charging a minimum rate. Consciously or unconsciously, the charging of a minimum rate was the beginning of an effort to make each water taker pay his share of the "overhead;" and the fact that it did not quite accomplish this end is now evidenced by the tendency toward the substitution for it of a "service charge."

The amount of the minimum rate depended, variously, on "what the traffic would bear," on what neighboring towns were charging, on the desire of councils or other governing bodies for re-election and very seldom, on the cost of the service. In Cleveland, where there are several minimum rates in effect, there is one of $5 per annum, which applies to about 80,000 services, or perhaps 75 per cent, and permits the use of 12,500 cubic feet (93,750 gallons) without further charge, about twice as much as the great majority of them use. Another minimum rate of $2.50 per annum was put in effect at the beginning of universal metering, to cover the case of small houses, mentioned above, that paid flat rates of less than $5 per annum. This rate originally applied to about 10,000 services but, on the eve of an election, was extended to apply to about 10,000 more and is now in effect on about 25,000 services. As this rate permits the use of 6,250 cubic feet (46,875 gallons) without further charge, it goes without saying that it is not a profitable rate for the water department.

In general terms, the amount of a service charge depends on the size of the service; what it costs to read and maintain the meter; interest on original cost of meter and service, where these are installed at the cost of the water works; office expense and perhaps some other items.

It should be collected from every service that is capable of being used, whether actually in use or not. Buildings temporarily vacant should not be excepted, though it might be abated in the case of buildings actually destroyed or removed. In the latter case, if the owner had not paid for the installation of the service, and it was to be entirely discontinued, it would be proper to charge him with the original cost less salvage, from which would be deducted the cost of removal. It is perhaps unnecessary to add that the service charge is entirely independent of the charge for water used and would be a fixed amount, probably collected most conveniently annually or semi-annually in advance.

In his paper, quoted above, Mr. Earl says:

> If a certain amount of annual payment is the average that is necessary to pay the interest on the first cost of a certain sized connection and meter, to maintain it in operation and eventually to renew it; to read the meter, keep the accounts and make the collection; then that amount or that amount plus a fair profit is a fair charge for this particular item of service, regardless of whether any water is used through the connection or not, or the amount

of water, or of the character or amount of plumbing inside the premises, or of the uses to which the water is put.

The annual service charge, worked out for New Orleans, from these premises, which included the cost of installation of both meter and service was: ⅝-inch, $4; ¾-inch, $5; 1-inch, $6.50; 1½-inch, $10.50; 2-inch, $14.50; 3-inch, $22; 4-inch, $36; 6-inch, $64; 8-inch, $97. This system gave general satisfaction and on January 1, 1915, the annual service charge was reduced to the followings amounts: ⅝-inch, $3; ¾-inch, $3.60; 1-inch, $4.80; 1½-inch, $7.20; 2-inch, $12; 3-inch, $13.50; 4-inch, $24; 6-inch, $42; 8-inch, $76.

Do water meters increase water bills?. This question apparently assumes that consumers, previously paying a flat rate, have meters installed and it can be answered as variously as there are concrete examples of that condition.

Here in Cleveland, about twelve years ago, when operations looking to universal metering had covered about 50 per cent of all services, about 30,000 in all being then metered, I determined that about 93 per cent of those metered had saved money by the operation. That is, about that percentage paid, with meters, only the minimum rate of $5 or $6, then in effect, where they had previously been paying flat rates of $10 to $20 or more.

As the revenue did not decrease in any such proportion, and indeed showed an actual increase, the obvious assumption is that the other 7 per cent more than made up for the loss of revenue from the 93 per cent. It seems to me, therefore, that the only general proposition that can be stated is that, given a flat rate that affords sufficient revenue and is properly adjusted to different classes of consumers, which means that it is high enough to cover all waste, the installation of meters and the fixing of meter rates at a point which will afford a similar revenue, will insure a reduction in rate to all consumers who do not waste water. The usually small numerical proportion of water wasters will, of course, pay more.

It follows that, where flat rates have been too low to afford sufficient revenue, as is the case with some municipal plants partially supported from general taxes, the introduction of meters is likely to cause a horizontal increase if at the same time it is attempted to withdraw the help derived from the tax duplicate; but in any plant which has had a high enough flat rate to make it self-sustaining, it has generally been capable of demonstration that the careful users have been "paying the freight" and the introduction of meters has been the means of shifting the burden to where it belonged.

Testing water meters. The testing of any measuring device is simply a comparison of it with a known standard. In the case of a water meter, this comparison should be made under conditions as nearly approaching those of actual service as possible; which means that water should come to it under average to maximum pressure and should leave it under at least enough back pressure to keep the meter entirely filled with water. For example, it would not be a fair test of a meter to bring the water to it under a 5-foot head nor to discharge it horizontally at the outlet, though most meters as made today, would show some registration even under those conditions and might even register accurately.

In my opinion, all new meters should be tested. A record of this test is often useful, for instance, in disputes over bills. In Cleveland, this test of $\frac{5}{8}$-inch meters was, and I think still is, made with $\frac{1}{2}$-inch and $\frac{1}{16}$-inch orifices at the outlet, by passing 10 cubic feet with the former and 1 cubic foot at the latter or at an approximate rate of 20 cubic feet per minute and 1 cubic foot in ten minutes, respectively. The rate of flow is of course the governing factor and the size of orifice for low-flow tests should be such as will give the desired rate.

I believe that water works engineers now generally recognize that accuracy at extremely low rates of flow can only be obtained at the sacrifice of other essential qualities, such as durability and capacity. For example, it would hardly be considered good practice to weigh coal on jewelers' scales. The commercial test of a meter, therefore, should be one determination at as near the rated capacity of the meter as the pressure at the testing plant will permit and one at the rate of flow of an average leaky faucet or water closet, or say 0.1 cubic foot per minute approximately. While 0.05 cubic foot per minute would not be unreasonable, tests on $\frac{1}{64}$-inch orifices consume much time and in my opinion do not serve any purpose commercially valuable. At some plants, the low flow test is made by merely seeing if the meter works at the low rate, but I believe it is better practice to have a record of a definite amount.

Meters should also be tested for record on being removed from a service and as most old meters do not register at as low a rate of flow as when new, the custom has grown up of testing such meters at different rates of flow, from large to small, until one is reached, at which the meter does not register.

For a small plant with few meters to test, a very satisfactory testing machine can be arranged with a platform scale of 1500 pounds capacity, a 50-gallon barrel, a quick-closing lever valve and an assortment of nozzles, galvanized pipe and fittings. For larger ones, half a dozen good machines, made by as many manufacturers, are on the market. The essential features of such a machine should be convenient devices enabling the quick placing and removal of meters for test; ready graduation of the outlet orifice, pressure gauges, etc. It should have a capacity of four to six meters at one time and it is convenient to be able to run two such lines of meters at the same time, one line being run on full opening and the other at low flow. Percentage beams on the scales are convenient but are difficult of comprehension by the class of labor that usually does meter testing. I found it more satisfactory, in the Cleveland plant, to test by volume, by means of a graduated glass gauge on the side of the tank. Testing by weight can be done with greater accuracy but the error in testing by volume is not large enough to affect the result seriously in a commercial test and this method is more easily comprehended by the average laborer. The tank should have a capacity of 10 cubic feet or 50 gallons, depending on the unit in use, and on machines permitting the running of two lines of meters at once, a second tank of 1 cubic foot or 10 gallons capacity is essential for low-flow tests.

Where there are many large meters to be tested, it is almost essential to have a large tank with a 4 or 6-inch connection, though it is common practice to test 3-inch meters or larger with a 2-inch maximum orifice. Cleveland has a 100 cubic foot tank for this purpose with a maximum orifice of 6 inches and in Baltimore the water department has a 1000 cubic foot tank, on which, as I remember it, 10-inch meters can be tested at full rate.

For testing small meters in service, the best results can be obtained with a measure, which should be sealed by the local authorities having charge of weights and measures. This measure should contain 2 cubic feet or 10 to 20 gallons, depending on the unit in use, and is preferable to a test meter or any testing machine in being easily comprehended by the average small water taker.

For testing large meters in place, it is usually necessary to use a test meter, which should be 1 to 2 inches in size, depending on the size of the meter to be tested. I adopted the method, fifteen years ago, of installing all meters, 2 inches and larger, and in some in-

stances, 1½-inch meters, with valves on both inlet and outlet, and a tap of appropriate size on the outlet side, between the meter and the valve, in which was inserted a nipple, carrying a wheel valve and hose connection. The test meter is connected by hose and another piece of hose is attached to its outlet side to obtain the necessary back pressure. All large meters in service, should be tested at least once a year and where the consumption is very large, perhaps more frequently.

The cost of this form of inspection will be very much more than counterbalanced by being able to correct underregistration due to wear or other causes.

THE FALLACY OF EXTENDING SERVICE CONNECTIONS TO THE CURB LINE PREVIOUS TO PAVING[1]

By John Wilson

If there is one thing upon which municipal engineers are united, it is in an effort to minimize the destruction of pavements by tearing them up for the purpose of laying subsurface conduits, piping, etc. The principal difficulty in the solution of this problem is due to the fact that it is impossible to ascertain beforehand to just what extent and in what manner unimproved property will eventually be improved.

Probably the most common method of overcoming these difficulties, and strange to say one that meets with general approval, is often embodied in a clause in the official order under which the work is done which reads about as follows: "And that all water, gas and sewer service pipe, where not already in, be extended to the curb line, and the cost thereof be assessed to the property benefited."

In compliance with an order of this kind there is practically but one thing to do and that is install a connection to every platted lot or piece of ground upon which a building may be constructed in the future. Thus, assuming the average width of lot as 35 feet, the water main will be tapped on each side and a service connection extended to the curb at intervals of that distance.

The cost of making such connections will vary widely according to the width of the improvement and the character of the excavation, but may in general be considered at about $18 for a $\frac{5}{8}$-inch pipe complete. The pavement surface necessary to disturb at a later date to install a similar connection we will estimate as 6 square yards. It is then apparent that the expenditure at the time of paving to insure the surface against being molested is approximately $3 per square yard, less whatever value the connection itself may have. In view of the fact that the above price is very nearly

[1] Read before the Minnesota Section at Minneapolis on December 2, 1916.

the cost of tearing up the pavement and replacing it, that the public is saved the inconvenience due to the opening in the street, and that the connection is available for use without further expense to the owner of the adjacent property, for all that portion of the service between the main and the curb, the practice would seem to be nothing more or less than good business foresight.

The very purpose and intent of a plat is to provide a definite piece of land for each individual householder, or a definite building site for each business house, etc. However, one man may utilize three lots in building his home, another may use a lot and a half, other lots may be re-subdivided and abut on other streets from those originally intended, or large buildings requiring the use of automatic sprinklers may be constructed, while there will always be a certain number of lots remaining entirely unimproved for a period exceeding the useful life of the pavement. Consequently, for one reason or another, many connections that are installed under such conditions will be wrongly placed, will be of a size unsuited for the service required or will be entirely useless, and, in fact, it is doubtful if over one-fourth of these connections are ever used at all.

For the sake of argument, we will assume that one-fourth of these connections are actually used within a period of 15 years from the date of installation, and that money is worth 6 per cent, also that the cost of tearing up and restoring the pavement surface to its original condition is $3 per square yard. Thus, in order to save the expense of restoring 6 yards of paving at a total cost of $18, an expenditure of $7.50 would be justified and a similar amount for the service connection in place, allowing nothing for depreciation. Our total expense for the four connections at $18 each, will be $72, whereas an expenditure not exceeding $15 was justified. This means that for every connection actually used there is a direct financial loss of $55 incurred by this system of blindly installing a connection to every lot.

Throughout the above discussion it is assumed that the placing of these connections previous to paving does tend to preserve the pavement surface and reduce the cost of maintenance, nevertheless every municipal engineer recognizes these newly constructed ditches as one of the most prolific sources of paving difficulties. It is almost impossible to secure satisfactory consolidation of the backfill in a large number of these trenches, and their elimination, as far as possible, is the most effective means of reducing paving maintenance.

For some reason or reasons, these unused connections seem subject to breaks and leaks to a much greater extent than those in actual service, and the annual loss of water, together with the damage done adjacent improvements and structures, is an item well worth considering. And in fact I believe that there are as many openings made in the pavements for the purpose of shutting off unused and leaky connections at the main as are ever eliminated by our mistaken foresight, which so often, like the Irishman's, "comes after."

Every water works superintendent has had more or less experience with the so-called springs under the street or roadway, which will finally turn out to be nothing more or less than a leak and the chances are about two to one it is in a service connection.

I remember one case where, the phenomenon of a spring on top of a fill of about 10 feet being pointed out to me, my suspicions were at once aroused, and it was only a few days before the spring had entirely dried up, notwithstanding the fact that it had been there as long as some of the adjacent property owners could remember. I have in mind another spring that I was somewhat suspicious of but was told that it had been there from the time the street had been graded; it was also pointed out that the water was perfectly clear, whereas, the city water contained much iron and would produce a red stain in the gutter. However, we finally located a leak, which, strange to say, was about 400 feet away and on another street. The water followed along an old ditch that had been filled in and finally found its way to the surface, and in the meantime had become pretty thoroughly filtered and all the iron removed.

If the public and the average city or village council were better informed as to the cost and nature of service connections, street maintenance would be materially simplified, property owners would be saved a very considerable expense as well as the water department or corporation, as the case may be.

It seems to me that a far better plan for all concerned is to leave the installation of these services entirely in the hands of the water department, which should install only such connections as they are reasonably sure will be utilized. And if other connections are required, which necessitate the opening of the pavement, this should be done by the street-paving department, which should take all reasonable precautions to do its work in such a way as to avoid after-settlement and insure a surface equal to that of the surrounding pavement. The cost of such work should be charged to the

water department which in turn may be reimbursed by the parties for whose benefit the work has been done. In this way a paver will not be responsible for a water-works job or a water-works man responsible for the condition of the pavement, but each will confine himself to his own work, with resulting profit to all concerned.

In the meantime water superintendents could do valuable service in perfecting their accounting system as to cost and nature of maintenance, which would go a long way toward pointing out the proper procedure in regard to all such matters.

SOCIETY AFFAIRS

THE AMERICAN COMMITTEE ON ELECTROLYSIS

The American Committee on Electrolysis was organized at the invitation of the American Institute of Electrical Engineers to study the subject of electrolysis through the coöperation of committees representing the American Electric Railway Association, American Gas Institute, American Railway Engineering Association, American Telephone and Telegraph Company, American Water Works Association, United States Bureau of Standards, National Electric Light Association, Natural Gas Association and the Institute itself. The committee held its first meeting in May, 1913; and in its work since then the American Water Works Association has been represented by A. D. Flinn, D. D. Jackson and E. E. Minor. It has recently printed for submission to the bodies represented in its membership a 153-page preliminary report. This document, while printed, is not published and consequently cannot be used in legal proceedings. Any member of the bodies represented on the committee can obtain copies of the report from the secretary of the American Institute of Electrical Engineers, 25 West 39th Street, New York, at $1 per copy.

The report opens with definitions of the technical terms relating to electrolysis and an explanation of the electro-chemical principles involved. The method of making electrical surveys of railways, systems of pipes, underground cables, bridges and buildings is stated, the instruments used are described, and the character of the records that should be kept is explained. There are sections on American and European practice in treating electrolysis problems, a bibliography, and tables of the current flow in cast iron pipe of different diameters for 1 millivolt drop per foot of continuous pipe. The committee says the report is intended only as a statement of facts, without any conclusions drawn from the facts, discussions of legal questions, or recommendations.

MINNESOTA SECTION

The Minnesota Section of the American Water Works Association was organized at a meeting held at the University of Minnesota, Minneapolis, on December 2, 1916. The attendance was 31. The temporary chairman, W. R. Young, explained the purposes of the association and the advantage of sectional meetings to bring together men interested in water works in the same district more frequently than once a year at the association's annual convention. The resident trustee of the association, F. W. Cappelen, requested the Section for instructions as to his vote upon the proposed separation of the editorial work connected with the association's publications from the secretarial work of the association. After discussion, the Section voted in favor of this separation. The chair appointed J. A. Jensen, Joseph Seibert and John Wilson as a nominating committee, which reported the following nominations: Chairman, F. W. Cappelen; vice-chairman, G. O. House; treasurer, W. R. Young; trustees, T. C. Gordon for three years, Wm. Todd for two years and D. A. Reed for one year. They were unanimously elected, and at a subsequent meeting elected H. A. Whittaker, secretary. The constitution and by-laws of the Section were printed in the JOURNAL for September, 1916, and provide for one annual meeting of the Section. After discussion it was voted to hold at least one more meeting annually, the time and place to be selected by the officers.

The following papers were presented: "Some Problems of the Water Works Executive," by G. O. House; "The Fallacy of Extending Service Connections to the Curb Line Previous to Paving," by John Wilson; "State Supervision of Public Water Supplies in Minnesota," by H. A. Whittaker.

NEW YORK SECTION.

A meeting of the New York Section was held at the Hotel Astor on December 20, 1916, with Allen Hazen in the chair.

The first speaker was J. H. Purdy, who explained the purpose of the Pennsylvania Water Works Association of which he is president. It was organized about twenty years ago to meet the danger of municipal competition then threatening private water companies, which alone form its membership. The organization undertook, first, to secure interpretation of the law which would prevent the

loss of the capital invested in privately owned plants through the unrestrained competition of public or municipal plants, and its influence was felt in the legal proceedings to secure justice for the investor and fair play for the private company. Second, it undertook to inform its members of the law and decisions made in securing for private companies a fair consideration of the value of their properties when municipalities sought to purchase them. As a result of this coöperative work through the association, the private water companies in Pennsylvania are free from municipal competition but can be taken over, under the law, by the municipalities they serve. The Pennsylvania Water Works Association was a pioneer advocate of the fundamental principles that have been adopted as a basis of a part of the rulings of most public service commissions established to regulate public utilities, the principal being that a regulated utility, which is a natural monopoly, should not be subject to competition so long as it performs its duties to the public satisfactorily. For example, in Wisconsin, if any privately owned utility would surrender its own charter and take out an indeterminate permit to do business, the municipality served can only take over the plant, if municipal ownership is desired, on the basis of a fair appraisal of the property. It cannot build a competing plant. That is one of the principles for which the Pennsylvania Water Works Association struggled hard, and the legal condition of private companies in the Commonwealth is now probably as good as in any other state.

The second speaker was Prof. Albert F. Ganz, professor of electrical engineering at Stevens Institute of Technology, who spoke informally with the aid of lantern slides on "Electrolysis." Those taking part in the subsequent discussion were H. V. Allen, D. F. Atkins, Edward S. Cole, D. W. French, Professor Ganz, Nicholas S. Hill, Prof. D. D. Jackson, F. T. Kemble, Henry B. Machen, Fred B. Nelson, Alexander Potter, and Hermann Rosentreter.

OBITUARY

James J. Campbell, Menominee, Michigan, died October 26, 1915.

Edward L. Peene, Yonkers, New York, died December 31, 1916.

R. E. Speakman, Brandon, Manatoba, Canada, died January 12, 1917.

NEW MEMBERS, ACTIVE

Robert M. Anderson, Stevens Institute, Hoboken, New Jersey.

Robert W. Angus, University of Toronto, Toronto, Ontario, Canada.

A. N. Bennett, Illinois State Water Survey, Urbana, Ill.

Madeleince Bixby, Illinois State Water Survey, Urbana, Ill.

Horace J. Cook, Kennebec Water District, Waterville, Me.

T. R. Cook, Water Commissioner, Toledo, Ohio.

Waldo S. Coulter, Consulting Engineer, 2 Rector Street, New York City, N. Y.

George B. Dusinberre, Water Commissioner, Cleveland, Ohio.

George W. Graff, Chemist, Filtration Plant, Kingston, New York.

Edman Greenfield, Illinois State Water Supply, Urbana, Ill.

William Durrell Hatfield, Illinois State Water Supply, Urbana, Ill.

Mentor Hetzer, Manager Water Company, Moundsville, West Virginia.

C. R. Holley, Superintendent Water Works, Bessemer, Michigan.

Harry Neville Jenks, Sanitary Engineer, Burma, India.

S. D. Kirkpatrick, Illinois State Water Survey, Urbana, Ill.

George D. Mackie, City Engineer, Moose Jaw, Sask., Canada.

Friend Lee Mickle, Illinois State Water Survey, Urbana, Ill.

August G. Nolte, Superintendent Filter Plant, St. Louis, Mo.

George Edward Rodman, Department of Water Supply, Gas and Electricity, New York City.

J. F. Schnellbach, Illinois State Water Survey, Urbana, Ill.

E. G. Wagner, Superintendent Water Works, Lewiston, Idaho.

NEW MEMBER, ASSOCIATE

R. U. V. Company, Water Sterilization, New York City, N. Y.

CHANGES OF ADDRESS

Members are requested to notify the Secretary promptly of any change in address.